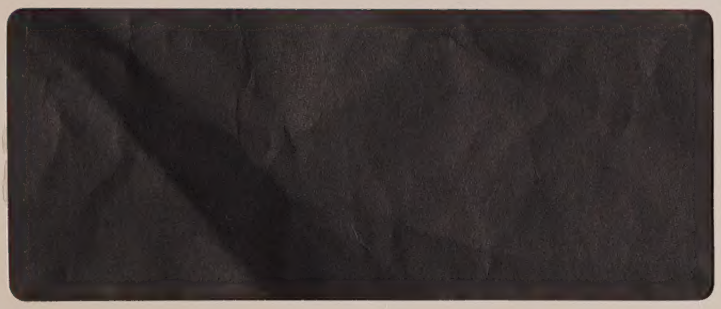
OPERATING AND SERVICE MANUAL

ID No.
K/24522
– RETURN TO –
INSTRUMENT CONTROL
SYLVANIA SES -- West



Issue 1

HEWLETT hp PACKARD

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from date of delivery, or in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

DC POWER SUPPLY

SCR-10 SERIES

MODEL 6477A

OPERATING AND SERVICE MANUAL

FOR SERIALS 5F0120* AND ABOVE

*For Serials Above 5F0120
Check for inclusion of
change page.

100 Locust Avenue, Berkeley Heights, New Jersey 07922

HP Part No. 06477-90001

Printed: September, 1968

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MANUAL CHANGES

DC POWER SUPPLY
Model 6477A
Manual Serial Number Prefix 5F

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
5F	0125 - up	1
ALL	-	Errata

CHANGE 1:

In the replaceable parts table, make the following changes:
CR41, 42, 49, 50, 57, 58: Delete these diodes.
R55, 61, 62. 69, 77: Delete these resistors.
R63, 71, 79: Change to 15KΩ, ±1%, 1/8W, hp Part No. 0757-0446.
R70, 78: Change to 61. 9KΩ, ±1%, 1/8W, hp Part No. 0757-0460.
Add VR6: 16. 2V, ±5%, hp Part No. 1902-0184.
Add new Printed Circuit Board: hp Part No. 5020-5756.

On the schematic diagram, in the three-phase firing circuits, make the following changes:
CR41, 42, 49, 50, 57, 58: Short-out all of these diodes.
R55: Delete R55 and connect new Zener diode, VR6 in its place. Anode of VR6 to +7. 4V and cathode to junction of R54, R63, R71 and R79.
R61, 62, 69, 77: Open-circuit these resistors.

The addition of the new printed circuit board (5020-5756) and the changes made to the existing circuit have all been included to enable the unit to operate with a line-to-line, rms input voltage unbalance of up to 8%. Prior to this change, the unit required that the line-to-line input voltages be balanced to within 1% of each other for proper operation

The new current balancing board (see schematic) is mounted on the forward, left-hand side of the unit. The board consists of two identical circuits; one for the phase "B" leg and the other for the phase "C" leg. Each circuit adjusts the firing angle of its SCR (CR29-phase B and CR30-phase C) so that the rms amplitude of the current flowing through it is equal to the current flowing through the SCR in the uncorrected (reference) leg for phase A.

The current balancing circuit for each of the corrected phases (B and C) receives its input directly from the appropriate input wire, which is run physically through the air-core of the input transformer (T1 or T2). Hence, each input wire serves as the primary of its input transformer, inducing the ac current flowing along that wire into the secondary winding. The ac current waveform on each input wire consists of positive and negative excursions. The positive current flows through the SCR associated with the input line while the negative current flows through a companion diode (CR31, CR32, or CR33) and is in fact, the return current from another phase. The return current for the reference phase (A) flows through diode CR32 and, therefore, appears on the phase B line as a negative going pulse. The return currents for phases B and C appear on the input lines of phases C and A, respectively.

It is the function of each current balancing circuit to maintain the amplitudes of these positive and negative input currents equal. The positive pulses are rectified by CR1/CR3, filtered by C1/C3, and the resultant positive dc current is applied to the base of Q1/Q3 via summing resistor R6/R16. The negative excursions are rectified by CR2/CR4, filtered by C2/C4, and the negative dc current is summed with the positive current by summing network R6, R7/R16, R17. If the amplitude of the positive and negative currents are unequal, an error signal is developed at the collector of Q1/Q3 and fed to the original three phase firing circuits at TP38/TP33. This error signal affects the bias on the base of Q18/Q17 and ultimately

advances or delays the firing of the SCR's; according to the polarity of the original error signal. Once the amplitudes of each of the positive and negative input currents become equal, no error signal is generated by Q1/Q3. In the preceding manner, the amplitudes of the currents for phases B and C are held equal to those of the reference phase, A.

Because of the addition of the current balancing circuit, the following paragraphs in the manual must be changed:

On Page 2-1, change Paragraph 2-6 to read as follows:

2-6 The ac power source to this supply may be either delta or wye with isolated neutral. The three-phase input voltages must be balanced to within 8% of each other for proper operation of this supply. Although the current balancing circuit in this unit permits operation with unbalanced input voltages of up to 8%, the output ripple balancing adjustment (Section V) should be made only if the line-to-line input voltages are found to be within 1% of each other. This limitation is necessary because of the interaction that exists between the output ripple potentiometers (R87, R88) and the current balancing circuit.

On Page 4-6, delete Paragraphs 4-35 and 4-36. The current balancing circuit now controls the amplitude of the voltage at C46 (and C41).

On Page 5-4, Paragraph 5-40, change Step a to read as follows:

a. Adjust R87 and R88 for presence of three phases and balanced ripple. (Input voltages must be balanced to within 1%, line-to-line, of each other before making this adjustment.)

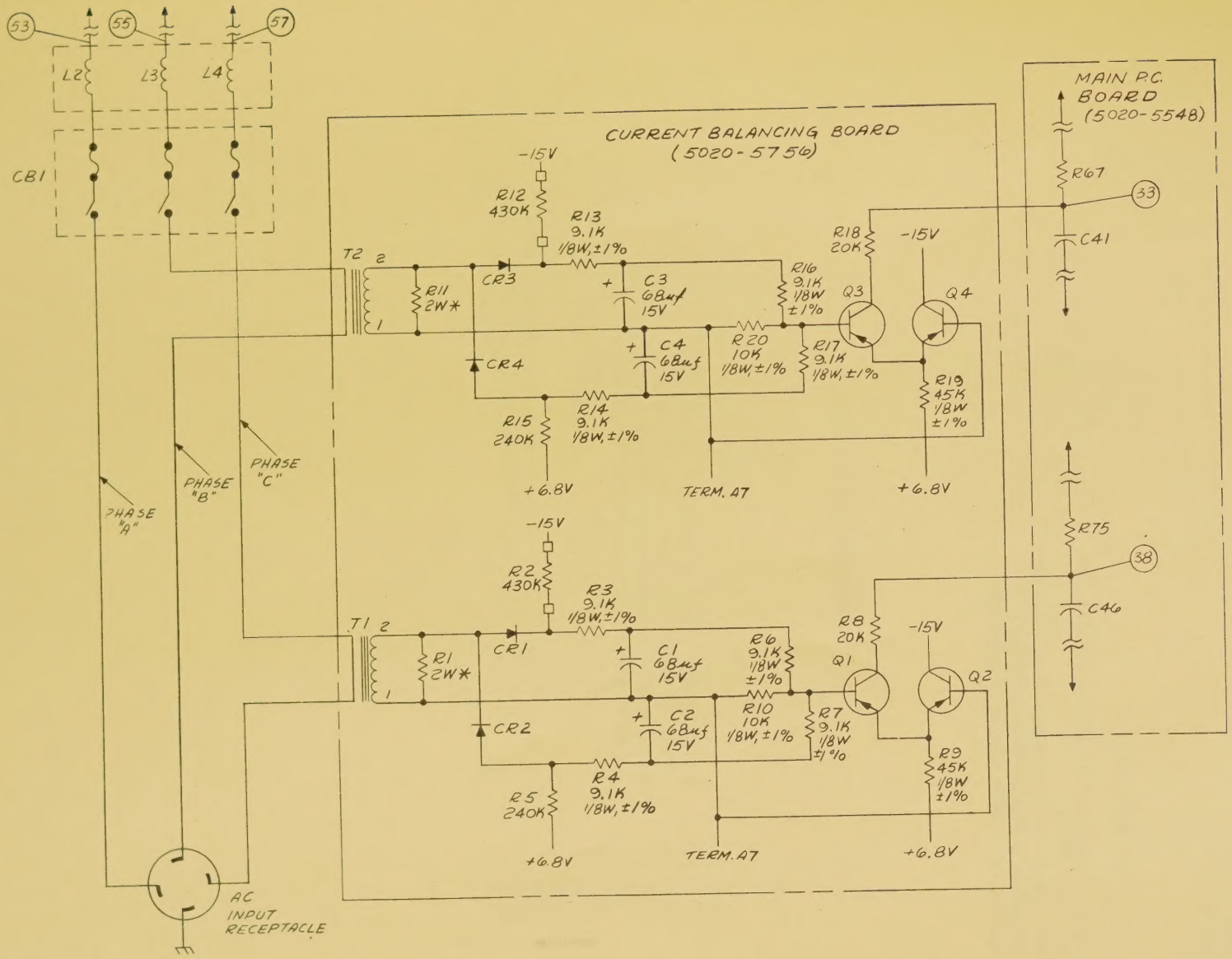
On Page 5-6, Paragraph 5-55, add the following:

NOTE

This adjustment should be made only if input voltages are balanced to within 1% of each other.

Replaceable Parts, Current Balancing Board

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	℗ PART NO.	RS
C1-C4	fxd, elect 68μf 15Vdc	4	150D686X0015R2	56289	0180-1835	1
CR1-CR4	Diode, Si. 200prv 200mW	4	1N485B	93332	1901-0033	4
Q1-Q4	SS PNP Si.	4		09182	1853-0010	4
R1	(208 & 230 Vac Input)					
	fxd, ww 10Ω ±5% 3W	2	242E1005	56289	0811-1718	1
	(380 Vac Input)					
	fxd, comp 18Ω ±5% 1W	2	GB-1805	01121	0689-1805	1
	(460 Vac Input)					
	fxd, met. ox. 22Ω ±5% 2W	2	Type C42S	16299	0698-3609	1
R2	fxd, comp 430KΩ ±5% ½W	2	Type EB	01121	0686-4345	1
R3, 4	fxd, met. film 9.1KΩ ±1% 1/8W	8	Type CEA T-O	07716	0757-0288	2
R5	fxd, comp 240KΩ ±5% ½W	2	Type EB	01121	0686-2445	1
R6, 7	fxd, met. film 9.1KΩ ±1% 1/8W		Type CEA T-O	01121	0757-0288	
R8	fxd, comp 20KΩ ±5% ½W	2	Type EB	01121	0686-2035	1
R9	fxd, met. film 45KΩ ±1% 1/8W	2	Type CEA T-O	07716	0698-5091	1
R10	fxd, met. film 10KΩ ±1% 1/8W	2	Type CEA T-O	07716	0757-0442	1
R11	SAME AS R1					
R12	fxd, comp 430KΩ ±5% ½W		Type EB	01121	0686-4345	
R13, 14	fxd, met. film 9.1KΩ ±1% 1/8W		Type CEA T-O	07716	0757-0288	
R15	fxd, comp 240KΩ ±5% ½W		Type EB	01121	0686-2445	
R16, 17	fxd, met. film 9.1KΩ ±1% 1/8W		Type CEA T-O	07716	0757-0288	
R18	fxd, comp 20KΩ ±1% ½W		Type EB	01121	0686-2035	
R19	fxd, met. film 45KΩ ±1% 1/8W		Type CEA T-O	07716	0698-5091	
R20	fxd, met. film 10KΩ ±1% 1/8W		Type CEA T-O	07716	0757-0442	



NOTES:
* 22Ω FOR 460VAC
10Ω FOR 208 & 230VAC
18Ω FOR 380VAC

Current Balancing Circuit, Schematic Diagram

▶ERRATA:

On Page 2-1, Paragraph 2-5, change the last sentence to read as follows:

Input line current is 60 Amperes maximum (52 Amperes nominal) for a 208Vac line, dictating that each conductor be at least number 8 gauge wire.

2-24-69

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Issue 1

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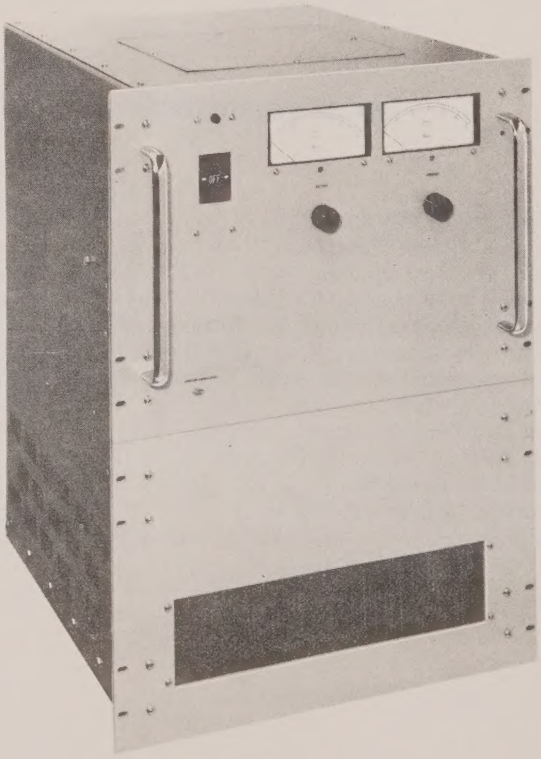


Figure 1-1. DC Power Supply, SCR-10 Series

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The SCR-10 Series of DC Power Supplies, Figure 1-1, are completely solid state regulated. They will supply full rated output voltage at the maximum output rated current or can be continuously adjusted for both voltage and current throughout the output range. The current limit can be set at any current from zero to the maximum rated to protect load elements at any predetermined current level.

1-3 Two meters measure load current and load voltage at the output terminals of the supply. Protection circuits incorporated in this supply are designed to protect the unit against overload conditions generated by the load device and failures in the input power line, while protection against failures in the internal main power mesh is accomplished by means of the three phase circuit breaker on the front panel. The breaker also serves as the on-off switch for the supply.

1-4 Input power is connected by means of a four-pin connector at the rear of the unit. Output power connections and programming connections for the various modes of operation are also made at rear of the unit. The output terminals consist of heavy bus bars connected directly to the output capacitors for improved high-frequency performance.

1-5 The programming terminals located at the rear of the unit allow the easy adaptation to remote sensing of the output voltage and remote programming of the output voltage or current.

1-6 Detailed specifications are given in Table 1-1.

1-7 COOLING EQUIPMENT

1-8 The operation of this unit under high load conditions requires that air be circulated through a compartment containing the heat-producing elements in the circuit. This circulation is by means of a fan located in the compartment with air flowing from bottom to top. Periodic cleaning to remove dust should be performed regularly as discussed in Section V.

1-9 EQUIPMENT SUPPLIED

1-10 SCR-10 power supplies are self-contained and require no auxilliary equipment.

1-11 INSTRUMENT IDENTIFICATION

1-12 Hewlett-Packard power supplies are identified by a three-part serial number tag. The first part is the power supply model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through L designates the month, January through December respectively. The third part is the power supply serial number.

1-13 If the serial number prefix on your power supply does not agree with the prefix on the title page of this manual, change sheets are supplied with the manual to define the differences (update or backdate the manual).

1-14 ORDERING ADDITIONAL MANUALS

1-15 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and -hp- stock number provided on the title page.

Table 1-1. Specifications

INPUT:
208/230/460VAC ±10%, 60 cycles, three phase.

OUTPUT:
0-220 VDC, 0-50A

COMBINED LINE AND LOAD REGULATION:
Constant Voltage -- Less than 0.2% plus 100 millivolts for a full load to no load change in output current combined with a ±10% change in line voltage.
Constant Current -- Less than 1% or 0.5 amp whichever is greater for a full change in output voltage combined with a ±10% change in line voltage.

RIPPLE AND NOISE:
Less than 0.15% maximum output voltage for any combination of line voltage, output voltage, and load current.

TRANSIENT RECOVERY TIME:
Less than 50 milliseconds is required for output voltage recovery to within 2 volts of the nominal output voltage following a load change from full load to half load or half load to full load, or a change of 100 amps, whichever is greater.

OPERATING TEMPERATURE RANGE:
0 to 50°C.

TEMPERATURE COEFFICIENT:
Output voltage change per degree Centigrade is less than 0.05% plus 2 millivolts.

STABILITY:
As a constant voltage source, the total drift for 8 hours (after 30 minutes warm-up) at a constant ambient is less than 0.25% plus 10 millivolts.

OVERLOAD PROTECTION:
The supply is protected for all overload conditions, including a short circuit at the output terminals. This protection is inherent in the constant voltage/constant current automatic crossover operation. The current control acts as a continuously acting limit in constant voltage operation and the voltage control acts as a voltage limit in constant current operation.

COOLING:
Internal fan provides forced air cooling of heat producing components.

AC LINE DROPOUT PROTECTION:
Protection is provided against an input AC line phase dropout. The supply senses the reduction of input voltage and turns off the rectifiers. When the input returns to normal, output power is automatically reapplied to the load.

CONTROLS:
A single control makes possible continuous adjustment of the output voltage over the entire range from 0 to 220 volts. The current control knob permits adjustment for maximum output current to the optimum value for protection of the load device. In addition, this latter control serves as the output control for constant current operation. The three phase circuit breaker serves as the ON-OFF control and as secondary protection to the instrument.

METERS:
A 0-250V voltmeter and 0-60A ammeter are provided on the front panel. Internal meter calibration potentiometers are provided.

TERMINALS:
Output power connections are made on two tapped rectangular bus bars located at the rear of the supply. Both power supply output terminals are isolated from the chassis and either the positive or negative terminal may be connected to chassis ground. The upper bus bar is positive.

ERROR SENSING:
Remote error sensing can be accomplished from the rear programming strip.

REMOTE PROGRAMMING:
Remote programming terminals make possible external control of the output voltage or current by resistance programming or voltage programming. Resistance programming in constant voltage is approximately 300 ohms per volt. Resistance programming in constant current is approximately 4 ohms per amp.

SIZE:
26-1/4" H x 22" D x 19" W (Standard relay rack mounting).

WEIGHT:
420 lbs. (approximately).

FINISH:
Light gray panel with dark gray case.

SECTION II
INSTALLATION

2-1 UNPACKING AND MECHANICAL INSPECTION

2-2 Before shipment, the power supply was inspected and found free of mechanical and electrical defects. If damage to the shipping carton is evident, ask that the carrier's agent be present when the power supply is unpacked. As soon as the power supply is unpacked, inspect it for any damage that may have occurred in transit. Also check the cushioning material for signs of severe stress (may be indication of internal damage). Save all packing material until the inspection is completed. If damage is found, proceed as instructed in the Claim for Damage in Shipment notice on the inside of the back cover of this manual.

2-3 Check that there are no broken knobs or connectors, that the external surface is not scratched or dented, that the meter face is not damaged, that all controls move freely.

2-4 LINE POWER

2-5 Because of the variety of line power connectors for three phase power sources, a power cord is not supplied, but a connector that mates to the input power receptacle on the unit is shipped with each new unit. The power cord and the plug for connection to the power source will be supplied by the buyer. Input line current is 52 Amperes maximum for a 208Vac line, dictating that each conductor be at least number 8 gauge wire.

2-6 The ac power source to this supply may be either delta or wye with isolated neutral. The three-phase input voltages must be balanced to within 1% of each other for proper operation of this supply. If the line voltages are found to be correctly balanced, then the output ripple voltage balance adjustment in Section V of this manual should be performed. If the line voltages are not balanced correctly, the three input line currents must be balanced instead of the output ripple. The three line currents should be balanced to within 10% of each other using the supply as a load. A clamp-on ammeter; such as the Dayton Model 4X221, is useful when balancing the line currents.

2-7 The SCR-10 Series as shipped is wired as specifically requested by the buyer in his original purchase contract.

2-8 Any SCR regulated supply, because of its inherent characteristics, cannot tolerate a great degree of distortion in the input line voltage. The amount of distortion that can be tolerated is not precisely defined, but the supply should never be driven from the output of an inverter or a saturable-reactor type of regulator where the nominally sinusoidal waveshape is flattened considerably. Another cause of distortion is a high line impedance. The user should contact the factory if trouble is experienced in this area.

2-9 PREPARATION FOR STORAGE AND SHIPMENT

2-10 The best method of packing the instrument is in the original shipping carton with the original fillers packed in the same manner as received from the factory. Therefore, when unpacking note carefully the method of packing and save the original packing material for possible future reuse.

2-11 If the original packing material is not available and it is desired to pack the instrument for storage or shipment, first wrap the instrument in heavy kraft paper to avoid scratching the paint, then pack the instrument is a cardboard carton with a bursting strength of at least 150 pounds per square inch. Pad the instrument on all sides with at least two inches of rubberized hair. Enclose the cardboard carton in a floating base type wooden carton and strap the carton securely to the base. Provide at least two inches of rubberized hair around the four sides of the box and between the box and the top of the crate.

2-12 STORAGE

2-13 No special precautions are necessary in storage of this unit except the usual protection against mechanical damage, salt air, etc.

2-14 INCOMING INSPECTION AND PERFORMANCE TEST

2-15 This instrument should be checked as soon as it is received to determine that its electrical characteristics have not been damaged in shipment. Refer to Section V for the performance test.

2-16 SITE SELECTION AND INSTALLATION

2-17 The SCR-10 Series should be mounted securely in a rack. In environments of vibration the rear of the chassis should also be fastened securely. There should be sufficient space along the sides of the instrument to permit free flow of cooling air. This instrument will fit any standard 19 inch rack. If the rack is not accessible from the rear, plug the power cable into the input power receptacle, connect the load leads to the output terminals, and make any changes in the programming terminal strip that may be necessary before sliding the instrument into the rack. (If the rack is accessible from the rear, these connections may be made at any time.) Secure the instrument to the rack with screws and cup washers. Connect the power cable to the power source.

SECTION III
OPERATING INSTRUCTIONS

3-1 PRELIMINARY CONSIDERATIONS

3-2 Model 6483B can be operated in three voltage ranges; each range has a certain maximum output current as follows:

0 - 600 Volts	0 - 15 Amps
0 - 500 Volts	0 - 20 Amps
0 - 440 Volts	0 - 25 Amps

As the rated output current is exceeded, the supply will begin regulating properly. At higher output currents, the output voltage will decrease proportionally.

3-3 Check the strapping pattern on the rear terminals for the proper connection of the rear. Make sure that all binding head machine screws on the rear barrier strip are tight. Many troubles can arise if these straps are not making connection. Determine the type of operation and make certain that the rear barrier strip straps are connected for the operation desired. The power supply as furnished from the factory has a strapping arrangement as shown in Figure 3-1.

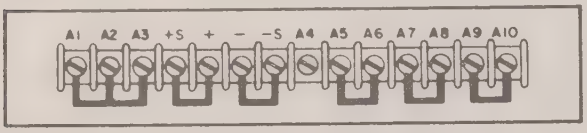


Figure 3-1. Normal Strapping, Wiring Diagram

3-4 CONNECTIONS TO LOAD

3-5 The load is applied to rectangular bus bars at the rear. The upper bus is positive.

3-6 Sensing is accomplished at rear terminals of the power supply as shipped from the factory. The user should be cognizant of the voltage drop which will occur in the load leads, and minimize the drop by using large size cable and minimizing the lead length to the load. Regulation at the load can be maintained within the specifications of the power supply by using remote sensing as described in this section of the manual.

3-7 CONSTANT CURRENT

3-8 The constant current circuit in the SCR-10 Series serves two purposes. It protects the power supply and load, and it allows the supply to act as a constant current power source. If only a coarse current limit is required, the current control knob can be set somewhat above the point at which the supply will switch into constant current operation and be controlled by the current knob. In instances where the current limit need be set more precisely, the following procedure should be followed:

1. Turn the VOLTAGE and CURRENT controls full counterclockwise.
2. Place a short circuit across the output terminals of the supply.
3. Slowly rotate the VOLTAGE control clockwise about one-half turn.
4. Bring up the CURRENT control until the output current as read on the front panel meter reads the desired value of current.
5. Rotate the VOLTAGE control fully counterclockwise, remove the short circuit, reapply the normal load, and adjust the output voltage to the desired setting.

3-9 When operating in the constant current mode, the voltage control can be adjusted for overvoltage protection.

3-10 REMOTE SENSING

3-11 In cases where the load device is remote from the power supply, resulting in poor load regulation at the load terminals, remote sensing can be used, Figure 3-2. As shipped, the power supply senses the output voltage at the output terminals of the supply and any IR drop in the leads between the power supply and the load causes a consequent degradation of the regulation at the load terminals. By sensing the output voltage at the load device terminals, these IR drops are effectively eliminated. The procedure for sensing the load at a remote location is as follows:

1. Turn off the front panel circuit breaker and remove the power cord from the power source.
2. On the barrier terminal strip on the rear of the unit remove jumpers (+S to +) and (-S to -).
3. Connect a pair of leads (#20 gauge wire) between +S and the positive terminal of the remote load and between the -S terminal of the supply and the negative terminal of the remote load.

4. Reconnect the AC power and turn on the power supply.

NOTE

The maximum IR drop that can be contained in the negative bus by means of remote sensing is three volts.

3-12 Although the use of remote sensing improves the DC load regulation at the load, it is important to note that the impedance at the load terminals is no better than it was with local sensing. In order to bring about an improvement in the impedance, it is advisable to place a large electrolytic capacitor across the terminals of the remote load.

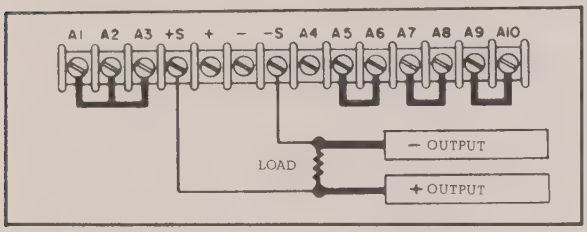


Figure 3-2. Remote Sensing, Wiring Diagram

3-13 REMOTE PROGRAMMING--CONSTANT VOLTAGE

3-14 The power supply may be programmed from a remote location by means of an external resistance or an external voltage. It is necessary to change the strapping pattern on the barrier strip at the rear.

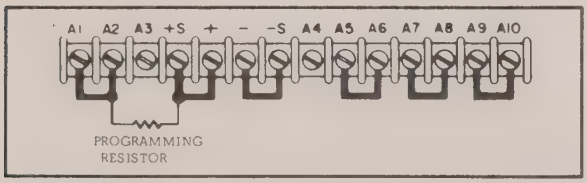


Figure 3-3. Remote Resistance Programming (Constant Voltage), Wiring Diagram

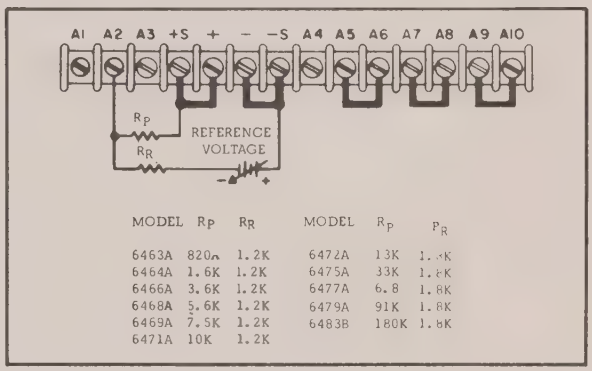
A. Resistance Programming (See Figure 3-3)

(1) A stable, low noise, low temperature coefficient programming resistor is recommended.

(2) The programming resistor takes the place of the front panel potentiometer.

(3) The output voltage will vary at a rate determined by the programming coefficient — 200 ohms per volt (i.e., the output voltage will vary 1 volt for each 200 ohms connected across the programming terminals). The programming coefficient is determined by the programming current. The current is factory adjusted to within 1% of 5mA for Models 6463A through 6469A and 3.3mA for Models 6471A through 6484A. If greater programming accuracy is required, it may be achieved by changing the shunt resistor, R8.

B. Voltage programming (See Figure 3-4)



MODEL	R_P	R_R	MODEL	R_P	P_R
6463A	820Ω	1.2K	6472A	13K	1.8K
6464A	1.6K	1.2K	6475A	33K	1.8K
6466A	3.6K	1.2K	6477A	6.8	1.8K
6468A	5.6K	1.2K	6479A	91K	1.8K
6469A	7.5K	1.2K	6483B	180K	1.8K
6471A	10K	1.2K			

Figure 3-4. Remote Voltage Programming (Constant Voltage), Wiring Diagram

(1) A stable, low noise, low temperature coefficient programming resistor is recommended.

(2) The values for R_R and R_P are given in Figure 3-4. R_P need not be used if the front panel C.V. potentiometer is left connected and set at the R_P value.

(3) The output voltage will vary linearly as the reference voltage is changed.

(4) The reference voltage in going from zero to -6 volts will change the supply output voltage from zero to the maximum rated output voltage. The maximum load on the reference voltage will be 5 milliamperes.

3-15 REMOTE PROGRAMMING--CONSTANT CURRENT

3-16 The power supply may be programmed from a remote location by means of an external resistance or an external voltage. It is necessary to change the strapping pattern on the barrier strip at the rear.

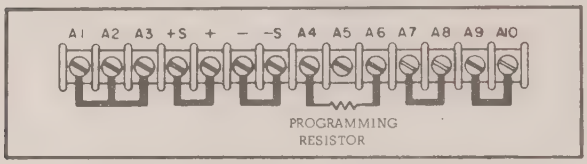


Figure 3-5. Remote Resistance Programming (Constant Current), Wiring Diagram

A. Resistance Programming (See Figure 3-5)

(1) A stable, low noise, low temperature coefficient programming resistor is recommended.

(2) The programming resistor takes the place of the front panel potentiometer.

(3) The output current will vary at a rate determined by the programming coefficient -- between 0.1 and 10 ohms per amp, depending on the Model. Refer to Table 1-1 for exact ratings. In the case of Model 6466A, for instance, the output current will vary one amp for each 1/3 ohm connected across the programming terminals. The programming coefficient is determined by the programming current. As a protection feature, the actual programming current has been set by the factory by turning the front panel current control potentiometer (230Ω) full C.W. and adjusting shunt R22 for a maximum current limit of 10% over the rated output.
This ratio, taking into account the offset voltage of the constant current differential amplifier, sets the coefficient between 0.1 and 10 ohms per amp. If greater programming accuracy is required, it may be achieved by reshunting R22 terminals.

B. Voltage Programming (See Figure 3-6)

(1) A stable, low noise, low temperature coefficient programming resistor is recommended.

(2) Rp = 200 ohms or this resistor need not be used if the front panel current potentiometer is left connected and set maximum C.W.

(3) The output current will vary linearly as the reference voltage is changed.

(4) For Rp = 200 ohms; the reference voltage in going from zero to +6 volts will change the supply output current from zero to the maximum rated output. The maximum load on the reference voltage will be 1.8 milliamperes.

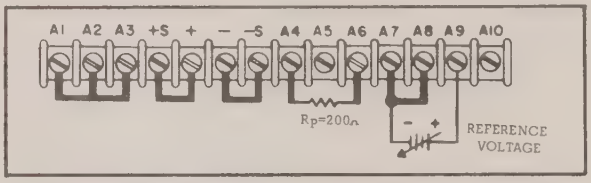


Figure 3-6. Remote Voltage Programming (Constant Current), Wiring Diagram

3-17 BATTERY CHARGING

3-18 The automatic transition between constant voltage and constant current displayed by the SCR-10 Series makes it an ideal supply for battery charging applications. Using this feature, a battery may be charged at a constant current until the maximum charge voltage is reached at which point the supply will revert to constant voltage and continue to supply a trickle charge current sufficient to maintain full charge, Figure 3-7. Thus, the charging operation can be unattended after properly setting the charging rate and the maximum charge voltage and connecting the battery to the output terminals of the supply.

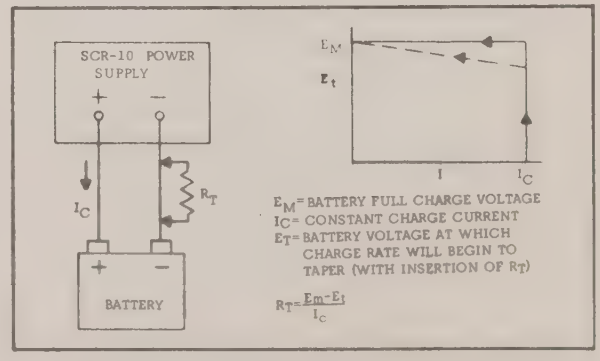


Figure 3-7. Battery Charging Diagram

3-19 The procedure for setting the charging rate and full charge voltage on SCR-10 Series power supplies is as follows:

1. Turn both the VOLTAGE and CURRENT controls full counterclockwise.

2. Place a short circuit across the output terminals and rotate the VOLTAGE control one half turn clockwise.

3. Rotate the CURRENT control to the desired charging rate as read on the front panel ammeter.

4. Rotate the VOLTAGE control full counterclockwise and remove the short circuit.

5. Rotate the VOLTAGE control to the desired full charge voltage as read on either the front panel voltmeter or a more precise voltage standard. The unit may then be connected to the battery terminals, positive to positive and negative to negative.

3-20 By inserting a small resistance in series with one of the load leads from the supply to the battery, it is possible to alter the normally rectangular charging plot in such a manner as to provide a taper charge for the last portion of the charge cycle. The value of this resistance is the difference between the full charge voltage and the voltage at which the tapering is to start, divided by the maximum charging current.

3-21 A large battery, connected as a load, presents a large capacitance across the output terminals. This capacitance can unbalance the feedback loop and cause the supply to oscillate; particularly if remote sensing is employed. To stabilize the feedback loop, the transient recovery potentiometer, R10, should be readjusted to increase its resistance. If the maximum resistance of R10 is not sufficient, an additional resistance should be placed in series with the potentiometer.

3-22 BATTERY DISCHARGING

3-23 Automatic constant current, unattended discharging of a battery using the SCR-10 Series requires certain changes in the strapping configuration on the rear barrier strip as illustrated in Figure 3-8. These changes include the removal of the jumpers from A1 to A2 and from A2 to A3 and the connection of A2 to the negative terminal of the battery through a 10K resistor. Make sure that the interconnecting leads between supply and battery are secure and cannot become opened.

3-24 The supply initially operates in constant current mode at the value set by the current control.

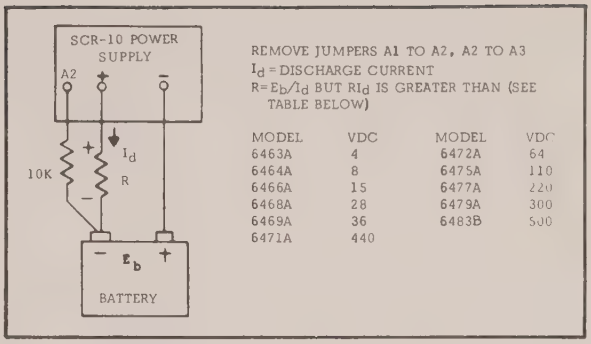


Figure 3-8. Battery Discharging Diagram

When the battery voltage is high the supply output voltage will be low, and as the battery discharges the supply output voltage increases. A constant voltage is maintained across R (constant current through R). This condition will prevail until the battery voltage drops to zero. At this point, the supply will switch off and no more current will flow through R.

3-25 The procedure for the connection of the components in this configuration is as follows:

1. De-energize the power supply and rotate the current control full counterclockwise. (The voltage control will be disconnected by step 2.)

2. Remove the designated jumpers (A1 to A2, A2 to A3) and connect A2 to the negative terminal of the battery.

3. Connect the negative terminal of the supply to the positive terminal of the battery.

4. Insert R between the positive terminal of the supply and the negative terminal of the battery, energize the supply and rotate the current control to the desired discharge current as read on the front panel meter.

3-26 MULTIPLE LOADING OF A POWER SUPPLY

3-27 It is imperative that each load have two separate leads brought directly back to the power supply terminal when connecting several pieces of equipment or subassemblies to the same power supply if full advantage is to be taken of the low impedance of the supply and mutual coupling effects between the equipment being powered are to be avoided.

3-28 AUTOMATIC CROSSOVER

3-29 There will be a time during which both the constant voltage input transistor and the constant current input transistor will be conducting. This will occur when the power supply has been operating

in the constant voltage mode of operation and is overloaded or when the power supply has been operating in the constant current mode of operation and the load is changed so that the output voltage reaches the voltage ceiling threshold. When operating in this crossover region, the regulation of the principal mode can be degraded. To prevent this, the control should be set to provide a margin of operation.

3-30 The current threshold should be set at a minimum of 10 Amperes greater than the maximum load current when operating in the constant voltage mode of operation.

3-31 The voltage threshold (open circuit voltage) should be set higher than the maximum operating output voltage when operating in the constant current mode of operation. The following list indicates the threshold voltage for each model:

Model	6463A	6464A	6466A	6468A	6469A
Voltage	4.5	9	20	31.5	41

Model	6471A	6472A	6475A	6477A	6479A
Voltage	55.8	70.5	118	230	310

Model	6483B	6484A
Voltage	510	610

3-32 MEASURING THE PERFORMANCE OF THE POWER SUPPLY

3-33 The measuring device (differential voltmeter, digital voltmeter, or oscilloscope) must be connected to the output terminals as close as possible to the supply when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. It is important that none of the output current flows through the lead lengths in series with the monitoring device since such lead lengths can easily have an impedance of the same order of magnitude as the supply impedance and thus effectively invalidate the measurement.

3-34 Connect either the positive or negative terminal of the supply to the chassis ground and the scope case to the same point, making certain that the scope case is not also grounded by some other means such as the power cord when measuring the power supply ripple. Connect both scope leads simultaneously to the power supply ground terminal to be doubly certain that the scope is not exhibiting a ripple or transient spike that is not coming from the power supply.

3-35 It is recommended that a four-terminal resistor be used to make constant current measurements.

SECTION IV
PRINCIPLES OF OPERATION

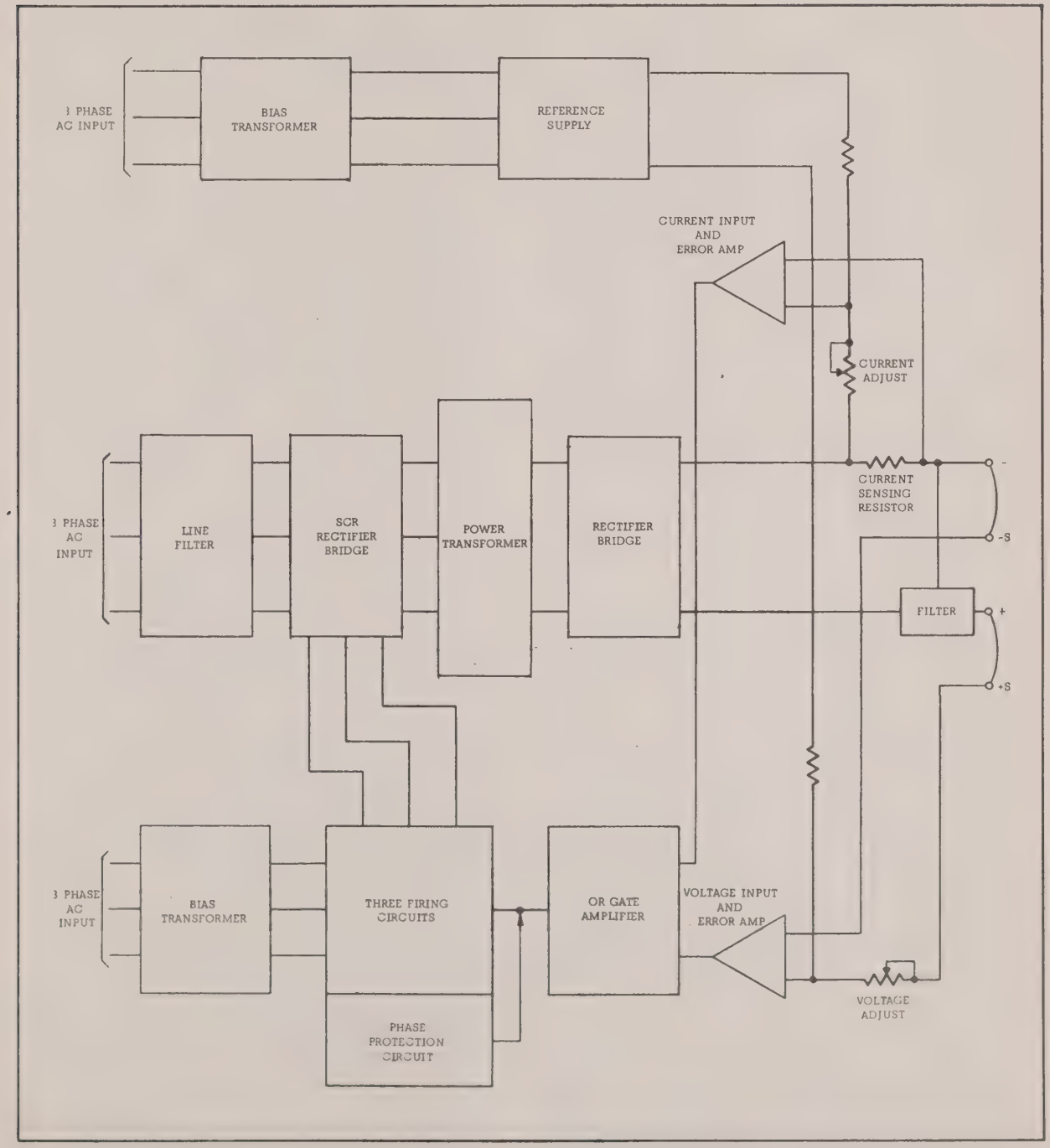


Figure 4-1. Block Diagram

4-1 BLOCK DIAGRAM

4-2 The block diagram, Figure 4-1, shows the basic parts of the power supply. The line voltage passes through the line filter and is controlled in the primary by the bridge circuit containing both fixed rectifiers and silicon-controlled rectifiers. The SCR turn-on firings are controlled in such a manner as to supply the desired output voltage and current to the secondary bridge. A separate bias transformer furnishes three phase voltage to the auxiliary rectifier for the bias supply and three phase voltage for the three firing circuits to operate on.

4-3 The dc current passes through the current sensing resistor connected in the negative bus. The voltage developed across the sensing resistor is the input to the current input amplifier. The output voltage of the power supply is monitored by the voltage input amplifier through the sensing terminals (+S and -S). Any changes in output voltage/current are detected in the constant voltage/current input amplifier, passed through the "or" gate, and applied to the firing circuits. The firing circuits control the SCR firing to counteract the change.

4-4 The "or" gate implements the constant voltage/constant current crossover operation of the supply. It allows one or the other amplifier signal to pass and control the loop but not both at once. The more restrictive signal, demanding less power output, is the controlling signal.

4-5 SIMPLIFIED SCHEMATIC

4-6 The simplified schematic, Figure 4-2, shows the various voltages used throughout the supply. The ammeter location, across the current sensing resistor R96, and the voltmeter location, across the output terminals of the power supply are shown. Across the output are the filter capacitors and together with choke L1 form the power filter. The rectifier bridge, CR12 through CR17, rectifies the ac from the transformer and also is a protection for the supplies if a reverse voltage is applied across the output terminals.

4-7 R104, R105, and CR66 function as a voltage ceiling circuit. When the output voltage at the positive terminal reaches the ceiling level, CR66 turns on, introducing a positive hold signal to the current input amplifier. Another protection feature is the phase protection circuit which stops operation if an input ac line phase opens or the line voltage drops below normal. The circuit samples the three input phases (from three diodes not shown in the simplified schematic) and in the event of failure turns off the control signal to the firing circuits. When the input returns to normal, firing pulses resume.

4-8 The function of the constant voltage input differential amplifier is to compare the reference voltage with the output voltage and to generate a correction signal if the output deviates from its prescribed value. One input to the amplifier is grounded to the negative output terminal -S while the other input is the summing point of output voltage and the -6.2Vdc reference voltage. When no error exists zero Volts is maintained between the amplifier input terminals. Any change in output voltage, whether it is due to a change in the setting of the front panel potentiometer or perhaps due to a change in load current tends to produce a voltage other than zero at this second input terminal. Feedback loop action thereafter is such to reduce this error to zero.

4-9 The action of the constant current input amplifier is similar to the constant voltage amplifier. The current sensing resistor, which monitors the output current, is a strip resistor located in the air blast along side the transformer. Four terminal connections are made to it, one sensing terminal constitutimg the reference for the constant current loop, the other the signal terminal going to the amplifier.

4-10 The three firing circuits receive the output of the "or" gate amplifier, mix this with an ac bias provided by the bias transformer windings, (this allows instantaneous correction for changes in line voltage) and generate firing pulses that turn on the silicon-controlled rectifiers in their respective phases at the precise time necessary to fulfill the feedback loop requirements. As can be seen in Figure 4-2, everything is done in triplicate. For each phase there is a transistor blocking oscillator with the third winding of the blocking oscillator transformer providing the gate pulse to the SCR gate leads. The three bias transformer windings are delta connected and the leads brought out to diodes CR43, CR51, and CR59. These diodes perform half wave rectification of the ac voltage. Thus, the voltage waveforms to input resistors R61, R69, and R77 are the same phase and shape as the waveforms across the SCR's in the primary rectifying bridge.

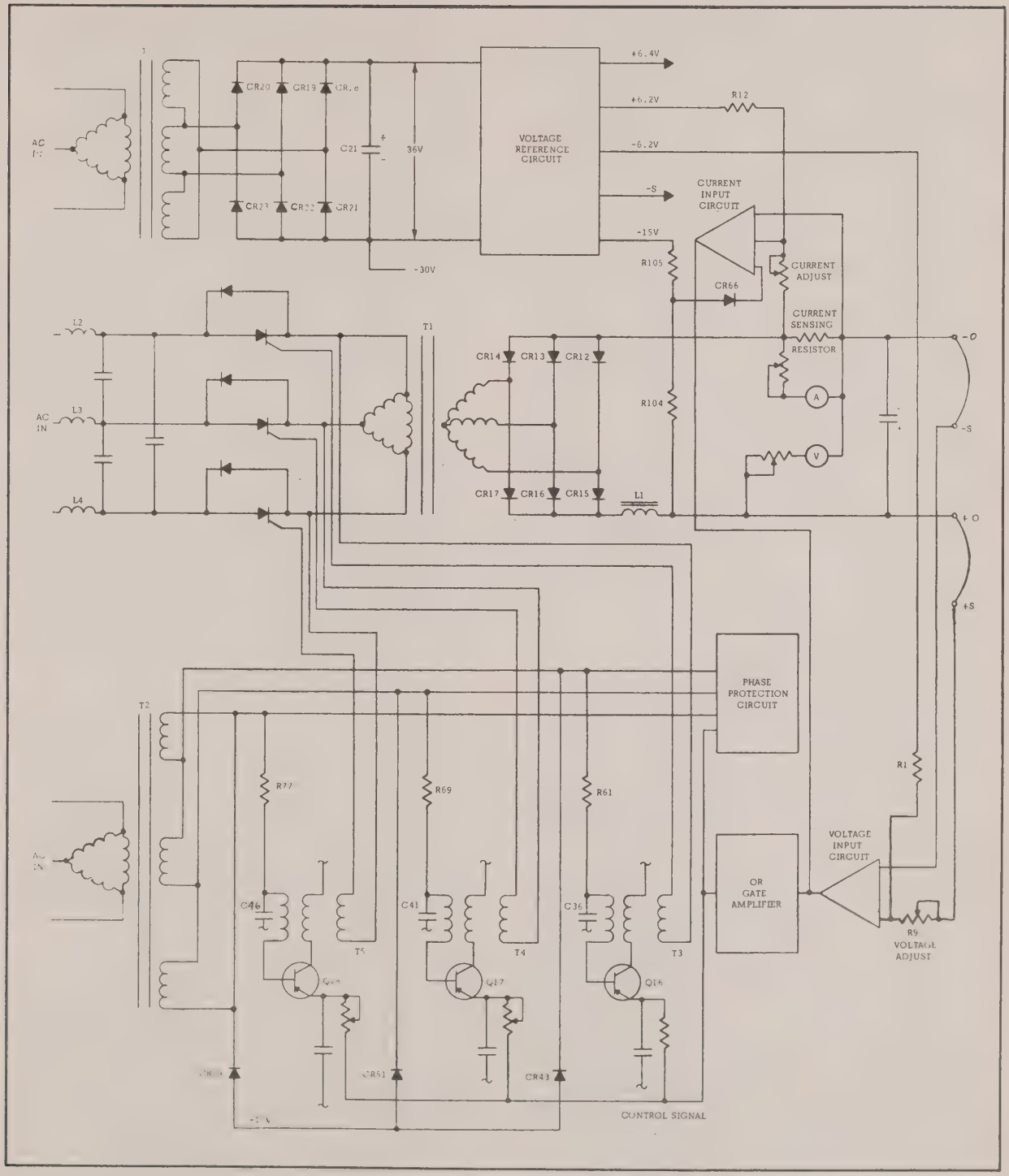


Figure 4-2. Simplified Schematic Diagram

4-11 MAIN RECTIFYING AND FILTERING CIRCUITS

(Refer to overall schematic at rear of manual.)

4-12 Three phase 60Hz line voltage is connected to the input LC line filter through a three phase common trip type circuit breaker which serves the dual function of ON/OFF switch and protection against failure in the main power mesh. The SCR bridge controls the amount of ac power applied to the primary of the transformer. In this full wave configuration each SCR has a fixed rectifier across it and so is never subjected to reverse voltage. The secondary is connected in wye to a full wave bridge of fixed rectifiers, CR12-CR17. These rectifiers are located on heat sinks at the front—bottom of the package. In addition to rectifying the ac they act together as a free wheeling diode, carrying the choke (L1 and L5) current for the parts of the cycle when no SCR is conducting, i.e., no input ac from the secondary. Due to the action of the choke and free wheeling diode the choke current is continuous, causing the SCR current to be rectangular. As a result the input ac rms line current at short circuit, maximum current, is two thirds that at full power. Also the rectifiers protect the output capacitors in case a reverse voltage is applied to the output terminals. (Such a case can occur in auto-series operation when the slave unit is de-energized while the master unit is energized.)

4-13 REFERENCE CIRCUIT

4-14 Three phase fullwave bridge windings on transformer T2 provide power for the auxiliary and reference voltages. Diodes CR18 through CR23 and capacitor C67 provide an unregulated -30Vdc (test point 20). All voltages are measured with respect to -S. The positive side of this unregulated auxiliary voltage is returned to +8.0Vdc.

4-15 Resistors R49, R50, R51, Zener diode VR3 and transistor Q14 form a shunt regulator whose output is -15Vdc (T.P. 17). In this configuration resistor R49 provides a constant bias current for VR3 (a 20-Volt zener diode). Any voltage variation across the shunt regulator is transmitted via the low impedance of VR3 to the base of the transistor. Q14 changes its collector current which is reflected in a voltage change across R51, reducing the variation. R50 reduces the power dissipation of Q14. C66 reduces ripple and causes a slow buildup of the -15 Volts at turn-on. The line regulation of this -15 Volt source is approximately ±100 millivolts for an input line change of ±10%.

4-16 R48, two 6.2 Volt zener diodes VR1 and VR2, and Q13 are connected in series from -15Vdc to +8.0Vdc. VR1 and VR2 produce the two reference voltages +6.2Vdc and -6.2Vdc. Any changes in the -15Vdc source are attenuated by the ratio of R48 to the forward impedance of the two diodes in series. Q13 acts as a shunt regulator for VR1, the base to emitter voltage and R47 determining the zener bias current. There is a large variation in the current returning through ±8.0Vdc to -S from other parts of the circuit and this bypasses VR1 through Q13.

4-17 CONSTANT VOLTAGE INPUT AMPLIFIER

4-18 Transistors Q1 and Q2 form a differential amplifier for the purpose of error detection and amplification in the voltage mode. The inputs of this amplifier are the bases of the two transistors. The output is the collector of Q1. The base of Q2 is considered the reference base and is connected to -S through R5 to achieve good thermal compensation. R6, from the base to the -6.2Vdc reference voltage, provides a slight negative bias voltage at the base to insure that the output of the power supply is adjustable to zero Volts. The base of Q1 is connected to summing point A2, which is the junction of current pullout resistor R1 and the front panel potentiometer R9. The control action continuously adjusts the output voltage on the positive bus to bring the voltage at A2 to the -S potential. With A2 held at the -S bus voltage, the voltage drop across R1 is the same as the reference voltage, and this voltage drop remains constant during operation. The current through R1, and thus through R9, likewise is held constant so that the IR voltage drop across R9 is determined solely by the resistance value of R9. Thus, the power supply output voltage is a linear function of the resistance of R9.

4-19 R2 in the base lead of Q1 limits the current through the programming resistance (pot) under conditions of rapid voltage turndown, and also isolates input and base for stabilizing the feedback loop. Diodes CR1 and CR2 limit voltage excursions on the base of Q1. Capacitor C1 bypasses the pot making the high frequency gain of the input circuit insensitive to pot setting. Capacitor C2 and adjustment pot R10 are located around the amplifier for loop stability.

4-20 CONSTANT CURRENT INPUT AMPLIFIER

4-21 Transistors Q4 and Q5 form a differential amplifier for the purpose of error detection and amplification in the current mode. The basic operation is the same as the constant voltage input amplifier. However, in the current mode, reference is with respect to sensing terminal A7 and the sensing resistor R96. R20 at the base of Q5 is normally connected to this reference. The resistor R96 requires four terminals to keep the voltage drop along the internal connections of the power supply from the sensing resistor to the (-) terminal from contributing to the input signal. The following components of the constant current input amplifier have functions as described for the voltage input amplifier:

R19 - Positive offset bias to base of Q5
CR5,CR6 - Protection diodes
R13 - Current limiting
C5 - Stability
R24 - Stability adjustment
R23 - Front panel current control pot
R12 - Current pullout resistor; sets programming current
R22 - Shunts R12; used for trimming adjustment.

4-22 Additional components are C4, and those associated with Q6. C4 reduces ripple voltage entering the amplifier. Q6 supplies one milliampere bias collector current to Q5 without shunting down the 47K load resistor R18. In this way, the dc gain of the constant current loop is increased. The bias current is fixed by the ratio of the forward voltage drop of CR7 and R17.

4-23 "OR" GATE AMPLIFIER

4-24 The OR gate receives signals from the two input amplifiers at the bases of Q8 and Q9. The most negative base signal tends to turn its transistor on harder. At that time, the negative voltage is transmitted to the common emitter and turns off the complimentary transistor. When the signal to either input amplifier increases above the level set by the control pot, the amplifier output moves negatively. This switches the OR gate and that amplifier controls the loop at its voltage/current setting.

4-25 The output of Q8/Q9 is amplified by Q10 to a suitable voltage level for controlling the firing circuits (Test Point 15):
Power supply OFF signal: Q10 saturated, collector at -13Vdc
Power supply just ON: -10Vdc
Maximum power: +2Vdc.
Diodes CR9 and CR10 at the emitter of Q10 provide 1.4Vdc bias voltage for the stage. Q11 is an emitter follower which transforms impedance so the firing circuit is driven from a voltage source.

4-26 An auxiliary feedback signal is connected from the input side of choke L1 (Test Point 14) to the base of Q10 via R28 and C8. Capacitor C9 performs three functions:
(1) Reduces ripple appearing from the input L1;
(2) Provides a frequency cutoff slope;
(3) Causes a slow turn-on signal buildup to the firing circuits.

4-27 SILICON-CONTROLLED RECTIFIER FIRING CIRCUITS

4-28 The SCR is a solid state device which displays high impedance characteristics with either positive or negative voltage on its anode but which may be switched into a high conductance state when positive voltage is supplied to the anode simultaneously with a gate signal application between its gate lead and its cathode. The gate signal that is used to turn on the device in the SCR-10 Series is a positive going pulse of about 50μsec duration and whose amplitude is approximately 3.5 Volts, this being the output of the blocking oscillator.

4-29 Each of the input phases has an SCR and a firing circuit associated with it. Each firing circuit generates an output pulse for its SCR once each cycle of input line frequency and so timed that each SCR conducts at identically the same phase angle in its respective phase.

4-30 The input to the three firing circuits is the output of the OR gate amplifier (transistor Q11 emitter) and is as previously mentioned a dc voltage referenced to -S and varying in amplitude between +2V and -10V as a function of the output conditions. This voltage is applied to three identical ramp capacitors (C35, C40, C45) through resistances R60, R87, R68, R76, and R88. The relatively high voltage signal produces current in each resistor which is integrated by the ramp capacitors to produce a steadily rising ramp voltage. R87 and R88 are pots which are adjusted to balance or nearly balance the ripple voltage on the output of the power supply.

4-31 Blocking Oscillator. A blocking oscillator is the firing circuit for each phase in the SCR-10 Series. The blocking oscillators (T3, T4, and T5) are triggered in to the conducting state by a transistor. Each output winding of the transformers (terminals 11 and 12 — TP25, 26, 30, 31, 35, 36) is connected between the gate and cathode leads of an SCR through a series current limiting resistor (R56, R64, and R72) with a diode connected in the reverse direction between gate and cathode of the SCR to prevent the possible appearance of a reverse spike or pulse on the gate of the SCR (CR36, CR44, and CR52).

4-32 The mechanism by which the blocking oscillator is triggered is by switching the transistor from the non-conducting state into the conducting state (transistor Q16, Q17, and Q18). The transistor has as its collector load one winding of the blocking oscillator transformer. Two windings are connected in series (for double voltage) in the base lead of the transistor. The base of the transistor follows the voltage of the base capacitor (C36, C41, and C46). The voltage on the emitter rises to meet the base at which time blocking oscillator action takes place. The start of current in the emitter of the transistor and the regenerative coupling that exists between the collector and base windings causes the transistor to go into saturation where it remains until the saturation region of the transformer is reached. At this point the coupling action collapses and the transistor returns to the nonconducting state.

4-33 Capacitors C34, C39, and C44 between the base and emitter prevent spurious triggering. Resistors R59, R67, and R75 in the base circuits limit the base current which flows during the blocking oscillator action. Upon conduction of the blocking oscillators, the ramp capacitors discharge negative with the emitter current and the base capacitors charge positive with base current. This prevents the blocking oscillator circuit from retriggering during that same cycle. At the end of the cycle these capacitors are reset for the next cycle.

4-34 Firing Angle Determination. Determination of the proper firing angle is accomplished by mixing two signals in the blocking oscillator circuit, these two signals being a reflection of the output conditions and the input line conditions. A ramp voltage whose origin is approximately -17Vdc and whose slope is a function of output voltage and output current is subtracted from a halfwave rectified voltage whose amplitude is a function of the input line voltage.

4-35 The three-phase bridge circuit providing voltage to the firing circuits consists of windings 6, 7 on the main transformer and diodes CR43, CR51, and CR59. This bridge provides the waveshape shown in Figure 4-3 to the firing circuits through R61, R69, and R77. R78 reduces the amplitude of the signal from R77, and C46 charges toward the positive peak. The integrating action of C46, along with diode CR57, provides a smooth voltage shape at C46 with the amplitude still a function of line voltage.

4-36 Line Compensation. If the input ac line voltage increases from nominal, the voltage wave amplitude at C46, the base of Q18, increases. Then more time is taken for the ramp at the emitter to catch the base voltage and SCR firing is delayed. The decreased firing conduction angle compensates for the larger voltage available at the input.

4-37 Reset Operation. At the end of each line cycle the ramp capacitor and base capacitor are reset to their starting voltages and operation repeats. The resetting operation is performed by the positive going rectified wave referenced to -15Vdc (see Figure 4-3), which is the input to the firing circuits at CR43, CR51, and CR59. These diodes with anode at -15Vdc set the reference level by clamping. Diode CR53 is always conducting; its bias current flows to the -30Vdc through R73. Thus, the voltage at the cathode of CR53 follows the input voltage from CR59. During the time that CR59 clamps, base capacitor C46 is held at about -16 Volts by CR59 and 53. C45 is held at about -17 Volts by CR59. The 0.7 Volt difference back biases the blocking oscillator transistor base to emitter junction. When the input voltage starts positive again, it rises rapidly; CR54 and 56 are cut off, and the base and emitter capacitors follow their input signals.

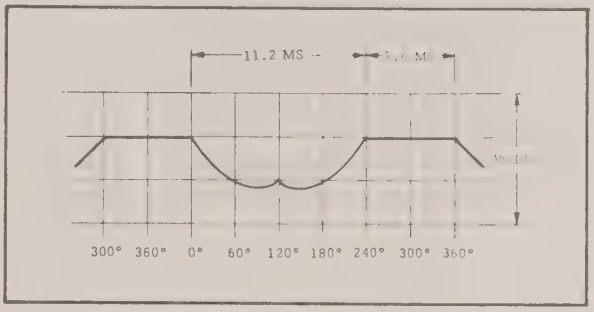


Figure 4-3. Three-Phase Firing Circuit Waveform

4-38 METERING CIRCUITS

4-39 Both voltmeter and ammeter circuits consist of a 1.0mA type movement with the calibrating resistors contained on the rear printed board. The voltmeter is connected across the output terminals and is calibrated by means of rheostat R99. The ammeter circuit is connected across the internal current monitoring resistor and is calibrated by means of rheostat R97.

4-40 PROTECTION CIRCUITS

4-41 One of the protection features incorporated in the SCR-10 Series is the internal connection of 100 ohm resistors (R91 and R93) between the sensing terminals and the output terminals. These resistors provide protection should the sensing lead become open (particularly when using remote sensing). These resistors insure that the output voltage will rise only slightly if a sensing lead should become open.

4-42 Another protection circuit incorporated into the SCR-10 Series insures that no damage will occur internally should one or more of the input phases fail. This circuit monitors the input voltage and upon such a failure clamps the control signal off. When the phase returns to normal, the operation reverses itself.

4-43 Diodes CR60, 61, 62 connected to the reset waveform of the three firing circuits and biased by resistor R113 connected back to the -30Vdc provide at their juncture (test point 49), a signal composed by the full wave rectification of the input phases. With the presence of three phases on the input, the average voltage at TP49 is positive enough to bias Q21 and Q20 ON. In the event of

failure of one or more phases, the average voltage becomes negative and reverse biases Q21 which turns off Q20. CR24 provides a 0.7 Volt reverse bias which Q21 overcomes to turn Q20 on. Q20 saturates, when on, holding its collector at +7.5 Volts.

4-44 The collector of Q20 is connected to R100, R101, and CR64 going to the constant voltage input amplifier, and to R37, going to the OR gate amplifier, to turn these off and on with the phase. CR54 and R101 provide a large time constant for positive going voltage to slowly turn the supply back on each reset time.

SECTION V
MAINTENANCE

5-1 PERFORMANCE CHECK

5-2 EQUIPMENT REQUIRED

1. Line cord (4 wire) and plug for connection to 208/230/460Vac 3 phase, 60Hz source.
2. Oscilloscope.
3. 100 Ampere shorting strap for output terminals.
4. Ohmmeter.

5-3 PROCEDURE

1. Measure the resistance to chassis ground from each output bus and from each phase pin on the ac power connector at the rear of the unit (pin C is connected to chassis ground internally) with the front panel circuit breaker in the ON position. Measure resistance should be in excess of one megohm on all measurements.

2. Check the ammeter and voltmeter on the front panel for zero set. If alignment is required, refer to Paragraph 5-9.

3. Rotate the front panel VOLTAGE control full counterclockwise (OFF) and the CURRENT control full clockwise (ON). Check the programming terminal strip on the rear of the unit for normal strapping (see Figure 3-1). Place the front panel circuit breaker in the OFF position. Connect an oscilloscope to the output terminals. Connect chassis ground to the negative output terminal.

4. Connect the line cord to the power supply, then to the power source.

5. The first test is at no load. Place the circuit breaker in the ON position. Front panel meters should both read zero.

6. Rotate the VOLTAGE control full clockwise. Output voltage should be 250 ± 12.5Vdc as read on the front panel voltmeter (ammeter should still read zero). Turn down voltage to 220Vdc. Output ripple should be approximately 0.99V peak to peak at 180Hz (one peak each 5.5 millisec.). At no load the voltage decay on turn-down will be quite slow because of the high output capacitance, even though there is a shunt bleeder resistor within the supply.

7. Rotate the CURRENT control full counterclockwise. Insure that supply turns off.

8. Rotate the front panel VOLTAGE and CURRENT controls full counterclockwise, de-energize the unit, and place a shorting strap across the output.

9. Rotate the VOLTAGE control clockwise about one half turn. Rotate the CURRENT control ON controlling the current to maximum and back again, reading the front panel ammeter.

10. Place the circuit breaker in the OFF position, rotate the VOLTAGE control counterclockwise. Remove the power cord from the power source and disconnect the short circuit across the output terminals.

5-4 POWER SUPPLY ADJUSTMENTS

5-5 METER ZERO-SETTING

5-6 The meter pointers must reset on the zero calibration mark on the meter scales when the instrument is at normal operating temperature, resting in its normal operation position and the instrument is turned off. To zero-set the meters proceed as follows:

1. Rotate adjustment screw on the front of the meter clockwise until the pointer is to the left of zero and further clockwise rotation will move the pointer up-scale towards zero.
2. Turn the adjustment screw clockwise until the pointer is exactly over the zero mark on the scale. If the screw is turned too far, repeat steps 1 and 2.
3. Turn meter adjustment screw counterclockwise about 15 degrees to break contact between adjustment screw and pointer mounting yoke, but not far enough to move the pointer back downscale. If the screw is turned too far, as shown by the needle moving, repeat the procedure. The meter is now zero-set for best accuracy and mechanical stability.

5-7 208/230/460 VAC OPERATION

5-8 To change the operation of the supply to another three phase 60Hz voltage, wiring should be done at the factory.

5-9 MECHANICAL MAINTENANCE

5-10 COOLING SYSTEM MAINTENANCE

5-11 The SCR-10 Series utilizes forced air cooling on the rectifiers and transformer, the secondary rectifiers are located in the bottom front of the unit, the primary SCR is above and behind them. As in

any forced air cooling system, the compartment should be cleaned regularly (regularity will depend on the cleanliness of the air in the surrounding area). Remove the top cover of the supply and clean with either a vacuum cleaner or with compressed air. Regular cleaning maintains the efficiency of the heat sinks and reduces the possibility of a short circuit to ground due to particle build-up around the rectifiers.

5-12 The blower motor bearing surfaces should be lubricated every six months as another preventitive maintenance procedure.

5-13 PRINTED CIRCUIT BOARD ACCESS

5-14 The printed circuit board in the SCR-10 Series is located in the top rear of the chassis. Access to the board may be accomplished by removal of the top cover.

5-15 Removal of the top cover provides access to the top (component side) of the board, but not to the bottom (copper side). The bottom of the board can be made accessible by removing the screws along the board.

CAUTION

Do not work on printed circuit boards before ac plug is removed and output capacitors are allowed to completely discharge.

5-16 Check that all wires are connected to the board (after work is completed) before replacing the board in its normal position.

5-17 PRINTED CIRCUIT BOARD SERVICING

5-18 Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 Watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick-drying acetate base cement having good electrical insulating properties.

5-19 A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

5-20 Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

5-21 When replacing components with multiple mounting pins such as transistor sockets and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

5-22 The procedure for the replacement of a component is as follows:

a. Apply heat sparingly to lead of component to be replaced on the conductor side of board. Remove component.

b. Reheat solder in vacant eyelets and quickly insert a small awl to clean inside of hole or drill out hole with a #60 drill (#50 for medium sized eyelet, #40 for large eyelet).

c. Bend the trimmed leads on new part and carefully insert through eyelets in board.

d. Hold part against board and solder leads on conductor side of board.

5-23 REPLACING SCR'S

5-24 Observe the following precaution when replacing the SCR's.

CAUTION

When replacing the regulator SCR's, use a torque wrench with a 0-150 inch pound capability. All SCR's must be installed with a torque of between 125 and 150 inch pounds. A torque below 125 inch pounds will result in a poor connection between the SCR and heat sink and the SCR will run too hot. If more than 150 inch pounds is used, the SCR could be broken.

5-25 TROUBLESHOOTING

5-26 GENERAL

5-27 Pre-Turn On Checks. Before energizing the unit, check the following items:

a. Presence of 230Vac (or 208/460) at the plug which connects to the receptacle on the rear of the unit. (Check three phases.)

b. Straps on the programming terminal strip on the rear of the unit are placed properly and tightened, Figure 3-1.

c. Visually inspect for broken leads on the printed circuit board, controls on the front panel and the meters. Inspect the main bridge for loose connections. Inspect the printed circuit board for burned, charred, or broken components.

NOTE

If a component is found to be burned, charred, or broken on the printed circuit board, the cause of such failure must then be located.

5-28 Open Loop. In certain types of power supply failures (such as uncontrolled output conditions) it is desirable to open the feedback loop in order to be able to troubleshoot the unit without exceeding voltage limits on the output capacitors, etc. In the SCR-10 Series, removal of transistors Q16, Q17, and Q18 (blocking oscillator transistors) breaks the loop between the error amplifiers and the SCR's by disabling the blocking oscillators.

a. If an output still exists after this test, the trouble probably lies in the main power bridge rectifier.

b. If no output exists, the trouble lies in or prior to the blocking oscillator circuit and trouble-shooting can proceed safely.

5-29 Resistance Measurements of Main Power Bridge Rectifiers. If a failure is suspected in the power rectifier bridge circuit, a resistance measurement will most often identify the faulty component. Breakdown of the reverse characteristic (or forward characteristic in the case of SCR's) may be determined by measuring the resistance from the anode on rectifier, cathode on SCR to their respective heat sink with the common side of the ohmmeter connected to the stud (heat sink).

5-30 Due to the characteristics of a bridge circuit, a resistance measurement test to find a faulty diode will not indicate which diode to be at fault. After finding a fault, it will be necessary to disconnect all the wires to the devices and make further measurements on the now disconnected diodes to determine which one is faulty.

5-31 When completely disconnected, SCR's should measure high resistance from cathode to anode and from gate to anode with either end connected to the common side of the ohmmeter. The resistance from gate to cathode should be approximately 200 ohms with either gate or cathode connected to the common side of the ohmmeter. The power rectifiers should read high resistance with the cathode connected to the common side, and lower resistance when the anode is connected to the common side. It is important to note that the stud is the cathode of the fixed rectifiers but is the anode of the SCR's.

5-32 DC VOLTAGES

5-33 All measurements given in Table 5-1 are made with a Simpson Model #269VOM at medium input line voltage and zero output conditions except as otherwise indicated. Polarities indicated are for first test point ("FROM") with respect to second test point. All voltages are ±10% unless noted otherwise.

Table 5-1. Voltage Measurements

STEP	FROM	TO	VOLTAGE	OUTPUT CONDITIONS
1	20	-out (or -S)	-30Vdc	360Hz ripple
2	17	-out	-15 ± 2Vdc	
3	18	-out	-6.2 ± 0.4Vdc	
4	A10	-out	+6.2 ± 0.4Vdc	
5	19	-out	+6.8 ± 0.4Vdc	
6	47	-out	-28Vdc	Phase protection circuit off (low line)
7	47	-out	+7.4Vdc	Phase on
8	12	-out	+5 ± 0.5Vdc	Voltage as indicated for constant voltage mode and supply producing output power. When voltage control is turned off, TP12 is about +0.5Vdc. When in constant current operation, TP12 is about +6Vdc.
9	13	-out	+5 ± 0.5Vdc	Voltage as indicated for constant current mode and supply producing output power. When current control turned off, TP13 is about +0.5Vdc.

Table 5-1. Voltage Measurements (Continued)

STEP	FROM	TO	VOLTAGE	OUTPUT CONDITIONS
10	15	-out	Control Signal	In constant voltage mode: voltage control off TP15 -13Vdc; voltage just on TP15 -10Vdc; maximum load TP15 +2Vdc.

5-34 INSULATION AND CONTINUITY TESTS

5-35 Good insulation should exist between chassis ground and the output busses. In cases where the output busses display a low resistance to chassis ground, insure that the condition is not caused by extreme dirt buildup in the cooling compartment (bridge rectifiers).

5-36 Continuity measurements as outlined below will indicate the condition of the connecting wires between the printed circuit board, the SCR's, and the output busses. Lack of continuity (in all instances, continuity means zero ohms resistance) can usually be traced to an open lead, most often where that lead is connected to an eyelet on a printed circuit board. Continuity should exist between:

a. The positive output bus and the + terminal on the printed circuit board.

b. The negative output bus and the - terminal on the printed circuit board.

c. Test points 25, 30, 35, and the gate leads of the SCR's (that is, continuity between 25 on the board and one SCR gate lead). Test points 26, 31, 36, and the cathode leads of the SCR's.

5-37 SYMPTOMS AND CLUES

5-38 Poor Load Regulation:

a. Reference voltage -6.2Vdc may be varying.

b. Insure that the current limit circuit is not starting to limit.

c. Insure the measurements of load regulation are done between +S and -S.

d. Check transistors Q1, Q2, Q8, Q10, Q11.

5-39 Poor Line Regulation:

a. Check for presence and stability of -6.2V dc, -15Vdc, and +6.8Vdc.

b. Insure that the current limit circuit is not starting to limit.

c. Check transistors Q1, Q2, Q8, Q10, Q11.

5-40 Excessive Ripple Voltage:

a. Lack of firing of one or more SCR, adjust R87 and R88 for presence of three phases and balance ripple.

b. Check the filter capacitors for a leaky or shorted unit. Failure will probably be indicated by a blown or protruding membrane on the exhaust valve near the terminals.

5-41 No Output or Uncontrolled Output:

a. Check meters.

b. Check presence of input power (all phases).

c. Check presence of -32Vdc, -15Vdc, -6.2V dc, +6.8Vdc.

d. Check the strapping on the rear programming terminal strip, particularly the voltage programming terminals.

e. Check that voltage at TP47 rises to +7.4V as line voltage is brought up.

f. Check TP12, 13, and 15 for voltage as described in Paragraph 5-33 (8, 9, and 10).

g. Check the bridge diodes (static and SCR's) with an ohmmeter for a faulty device.

h. Check for presence of gate pulses at SCR's.

5-42 Insufficient Output (Voltage and/or Current):

a. Check meters.

b. If insufficient voltage, insure that current limit is not operating.

c. Refer to Paragraph 5-41.

5-43 Current Limit Inoperative:

a. Check the straps on the programming terminal strip.

b. Check step 9 in Table 5-1.

c. Check transistor Q9.

5-44 Excessive Drift:

a. Check the stability of -6.2Vdc.

b. Check the VOLTAGE control for excessive noise (R9).

c. Check for cold solder joints and/or noisy resistors (R1, R2, R8).

d. Check transistors Q1, Q2.

5-45 DETAILED CALIBRATION PROCEDURE

5-46 GENERAL

5-47 The following calibration procedure should be performed only after definite indications exist of trouble in the unit or after components have been changed in the circuitry where the adjustments are located. Indiscriminate adjustment of the internal controls to refine the settings may actually cause trouble.

5-48 The calibration procedures may be performed independently.

5-49 The differential or digital voltmeter serves two functions: that of a voltage standard (0.1%), and as a measuring device for measuring changes in voltage of millivolts. In the case where neither a digital nor differential voltmeter is available, substitute means can be derived to perform the same functions. Incremental voltages may be measured by connecting a dc source (another power supply or a battery, whose output voltage is approximately equal to the supply output voltage) in opposition to the output of the supply under test and measuring the difference between the two voltages. By adjusting the bucking voltage equal to the supply voltage (within 0.5Vdc) the most sensitive scale of a multimeter can be used to detect changes as small as 20mV in the supply voltage (assuming the bucking voltage stability is significantly better than 20mV for the measuring period).

5-50 REQUIRED TEST EQUIPMENT

5-51 A list of the required test equipment is shown in Table 5-2, together with recommended manufacturers and model numbers. A test equipment wiring diagram is shown in Figure 5-1.

5-52 PROCEDURES

5-53 CALIBRATION OF VOLTAGE PROGRAMMING AND VOLTMETER

5-54 Proceed as follows to calibrate voltage programming and voltmeter:

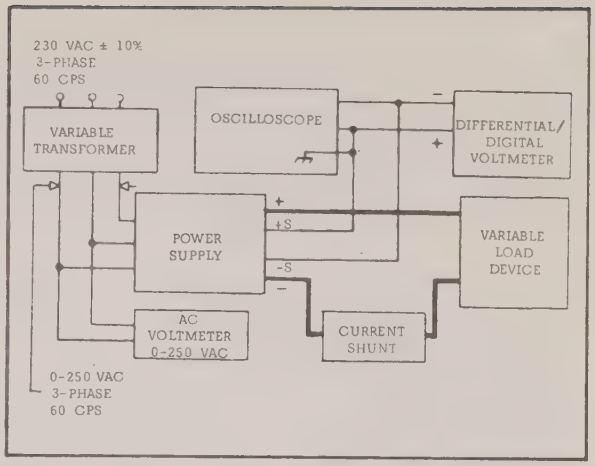


Figure 5-1. Test Setup Diagram

a. Connect differential/digital voltmeter to +S and -S terminals, rotate CURRENT control counterclockwise. Remove strap A2 to A3 on rear barrier strip to remove front panel pot from circuit. Connect a 66KΩ, 0.1% resistor between +S and A2 taking the place of the pot.

b. Energize power supply.

c. Rotate CURRENT control clockwise until supply is in constant voltage operation.

d. Set output voltage to 220Vdc ± 1.1V (as read on differential/digital voltmeter) by adjusting shunt R8 (across the pullout resistor R1).

e. Calibrate front panel voltmeter to voltage

Table 5-2. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS AND/OR USE	RECOMMENDED MODEL
Variable Transformer	18kVa - open delta - 0-270Vac	General Radio Variac Model W30HG2
Ammeter Shunt	Accurate to 0.5%. Provides 50mV output at 100A and is connected in series between load and supply.	Weston Model No. 41223
Voltmeter	0-250Vac voltmeter	Simpson Model No. 8800
Differential or Digital Voltmeter	Connected between +S and -S.	John Fluke Model 801H Differential Voltmeter
Oscilloscope	Connected to power supply line through 3:2 connector, vertical amplifier grounded to chassis ground.	hp 140A with 1400A Plug-In
Shorting Strap	Fabricated from copper bus strap or wire-connected as directed across output in series with meter shunt.	

measured on differential/digital voltmeter with R99.

f. Rotate CURRENT control counterclockwise turn power supply off and disconnect differential/digital voltmeter. Remove 66K resistor and replace strap A2 to A3.

5-55 FIRING CIRCUIT BALANCE ADJUSTMENT (Balanced output ripple voltage)

a. Connect oscilloscope to +S and -S terminals, connect load device to output terminals, rotate VOLTAGE control counterclockwise and CURRENT control clockwise.

b. Energize power supply.

c. Set output conditions to approximately 220Vdc and 50A as read on front panel meters.

d. Set oscilloscope to 100mV/cm and 5msec/cm with ac coupling to vertical amplifier.

e. Adjust R87 and R88 for minimum 60Hz modulation of output ripple.

f. Rotate VOLTAGE control counterclockwise turn power supply off and disconnect test equipment.

5-56 CALIBRATION OF CURRENT PROGRAMMING AND AMMETER

5-57 The factory sets the current programming as a protection feature for a current limit of 55 Amps at full pot setting. If more accurate programming is required, proceed as follows:

a. Connect load devices, rotate VOLTAGE control ccw. Remove strap from A5 to A6 on rear barrier strip (taking current front panel pot out of circuit). Connect a 200 ohm ±0.1% resistor between A4 and A6.

b. Energize power supply.

c. Rotate VOLTAGE control cw until supply is in constant current operation.

d. Set output current to 50 ±0.25 Amps by adjusting shunt R22 (across the pullout resistor R12).

e. Calibrate front panel ammeter to current output by adjusting R97.

f. Rotate voltage control ccw, turn supply OFF. Remove 200 ohm resistor from A4 to A6 and replace strap A5 to A6.

5-58 TRANSIENT RESPONSE ADJUSTMENT

a. Connect load devices, connect oscilloscope to +S and -S terminals, rotate VOLTAGE control counterclockwise and CURRENT control clockwise.

b. Set oscilloscope to 1V/cm ac and 50msec/cm sweep speed.

c. Energize power supply.

d. Set output voltage to 220Vdc and set load to switch from 220 Volts, 50 Amperes to 220 Volts, zero Amperes.

e. Switch load and observe that output voltage returns to within 2V of nominal within 50msec. If return is too slow or there is excessive ringing, adjust R10.

5-59 OVERVOLTAGE LIMIT ADJUSTMENT

a. Connect differential voltmeter and oscilloscope across sensing terminals (±S).

b. Connect decade resistance box in place of R103 (mounted on standoffs). Set at higher than nominal value, initially.

c. Select overvoltage limit by adjusting front panel VOLTAGE control until differential voltmeter reads anywhere between 230 - 330Vdc.

d. Reduce resistance of decade box, in 1KΩ steps, until output ripple, observed on oscilloscope, "jumps" radically.

e. Overvoltage limiting point is now set at output voltage selected in step c. Decrease decade resistance further and ensure that output voltage begins to decrease. Then increase decade resistance and repeat step d.

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts.

6-3 Table 6-4 lists parts in alpha-numerical order of the reference designators and provides the following information:

a. Reference Designators. For abbreviations, refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ) used in the instrument; given only first time the part number is listed.

d. Manufacturer's part number.

e. Manufacturer's code number. Refer to Table 6-3 for manufacturer's name and address.

f. ℗ Part Number.

g. Recommended spare parts quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Miscellaneous.

6-4 ORDERING INFORMATION

6-5 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses).

6-6 Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard part number.

c. Circuit reference designator.

d. Description.

6-7 To order a part not listed in Table 6-4, give a complete description of the part and include its function and location.

Table 6-1. Reference Designators

A = assembly	CR = diode
B = motor	DS = device, signaling (lamp)
C = capacitor	E = misc. electronic part
F = fuse	J = jack
K = relay	L = inductor
M = meter	P = plug
Q = transistor	R = resistor
RT = thermistor	S = switch
T = transformer	V = vacuum tube, neon bulb, photocell, etc.
X = socket	XF = fuseholder
XDS = lampholder	Z = network

Table 6-2. Description Abbreviations

a	= amperes	obd	= order by description
c	= carbon	p	= peak
cer	= ceramic	pc	= printed circuit board
coef	= coefficient	pf	= picofarads = 10^{-12} farads
com	= common	pp	= peak-to-peak
comp	= composition	ppm	= parts per million
conn	= connection	pos	= position(s)
crt	= cathode-ray tube	poly	= polystyrene
dep	= deposited	pot	= potentiometer
elect	= electrolytic	prv	= peak reverse voltage
encap	= encapsulated	rect	= rectifier
f	= farads	rot	= rotary
fxd	= fixed	rms	= root-mean-square
GE	= germanium	s-b	= slow-blow
grd	= ground(ed)	sect	= section(s)
h	= henries	Si	= silicon
Hg	= mercury	sil	= silver
impg	= impregnated	sl	= slide
ins	= insulation(ed)	td	= time delay
K	= kilo = 1000	TiO_2	= titanium dioxide
lin	= linear taper	tog	= toggle
log	= logarithmic taper	tol	= tolerance
mA	= milli = 10^{-3}	trim	= trimmer
M	= megohms	twt	= traveling wave tube
ma	= milliamperes	var	= variable
μ	= micro = 10^{-6}	w/	= with
mfr	= manufacturer	W	= watts
mtg	= mounting	w/o	= without
my	= mylar	cmo	= cabinet mount only
NC	= normally closed		
Ne	= neon		
NO	= normally open		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co.	New York, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Division	
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Commercial Receiving Tube and Semiconductor Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell-Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04713	Motorola, Inc., Semiconductor Products Division	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06486	North American Electronics, Inc.	Lynn, Mass.
06540	Amathom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Nuclear Corp. of America, Inc., U.S. Semcor Div.	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Semiconductor Div. of Fairchild Camera and Instrument Corp.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Products Inc. Mountain View Operations of Sylvania Electronic Systems	Mountain View, Calif.
07716	I. R. C. Inc.	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company	Sun Valley, Calif.
08730	Vemaline Products Co.	Franklin Lakes, N.J.
08863	Nylomatic Corp.	Morrisville, Pa.
09182	Hewlett-Packard Co., Harrison Division	Berkeley Heights, N.J.
09353	C & K Components	Newton, Mass.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11502	IRC Inc.	Boone, N.C.
11711	General Instrument Corp., Semiconductor Prod. Group, Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co., Inc.	Camden, N.J.
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co.	Dover, N.H.
14493	Hewlett-Packard Co., Loveland Division	Loveland, Colo.
14655	Cornell-Dubilier Elec. Corp.	Newark, N.J.
14936	General Instrument Corp., Semiconductor Prod. Group, Semiconductor Div.	Hicksville, N.Y.
15909	Daven Div. of Thos. Edison Industries, Mc Graw Edison Co.	Livingston, N.J.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
17803	Fairchild	Mountainview, Calif.
19315	The Bendix Corp., Eclipse Pioneer Div.	Teterboro, N.J.
19701	Electra Mfg. Co.	Independence, Kan.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp., Linde Div., Kemet Dept.	Mountain View, Calif.
22767	ITT Semiconductors, A Division of International Telephone & Telegraph Corp.	Palo Alto, Calif.
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26982	Dynacool Mfg. Co. Inc	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G. E., Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Mfg. Co., Microwave and Power Tube Div.	Waltham, Mass.
55026	Simpson Electric Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71400	Bussmann Mfg. Div. of Mc Graw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	I. T. T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Centralab Div. of Globe Union, Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71707	Coto-Coil	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72619	Dialight Corporation	Brooklyn, N.Y.
72699	General Instrument Corp., Capacitor Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp. of America	Union, N.J.
72982	Erie Technological Products, Inc.	Erie, Pa.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Components Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73978	Hardwick Hindle Co., Memcor Components Div.	Huntington, Ind.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Harvey Hubbel, Inc.	Bridgeport, Conn.
74868	FXR Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75183	Howard B. Jones Div., of Cinch Mfg. Corp. (Use 71785)	New York, N.Y.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Cinch	City of Industry, Calif.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., Bendix-Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry, Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronics, Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Elgin, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co., Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
79307	Whitehead Metal Products Co., Inc.	New York, N.Y.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries, Inc.	Racine, Wis.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co., Inc.	New York, N.Y.
82219	Sylvania Electric Products, Inc., Electronic Tube Division	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp., Electronic Components Div.	Plainfield, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	Radio Corp. of America, Electronic Components & Devices Div.	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco Industries Co.	Anaheim, Calif.
87216	Philco Corp. (Lansdale Div.)	Lansdale, Pa.
87585	Stockwell Rubber Co., Inc.	Philadelphia, Pa.
87929	B. M. Tower Co., Inc.	Bridgeport, Conn.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell, Inc., Micro Switch Div.	Freeport, Ill.
93332	Sylvania Electric Prod., Inc., Semiconductor Prod. Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	
94144	Raytheon Co., Components Div., Industrial Components Operation	Mansfield, Ohio
94154	Tung-Sol Electric, Inc.	Quincy, Mass.
94222	South Chester Corp.	Newark, N.J.
94310	Tru-Ohm Products, Memcor Components Div.	Chester, Pa.
95263	Leecraft Mfg. Co., Inc.	Huntington, Ind. Long Island City, N.Y.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Elect.	Franklin, Ind.
96791	Amphenol Controls Div. of Amphenol-Borg Electronics Corp.	Janesville, Wis.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000	Cooltron	Oakland, Calif.
00000	Plastic Ware Co.	Brooklyn, N.Y.

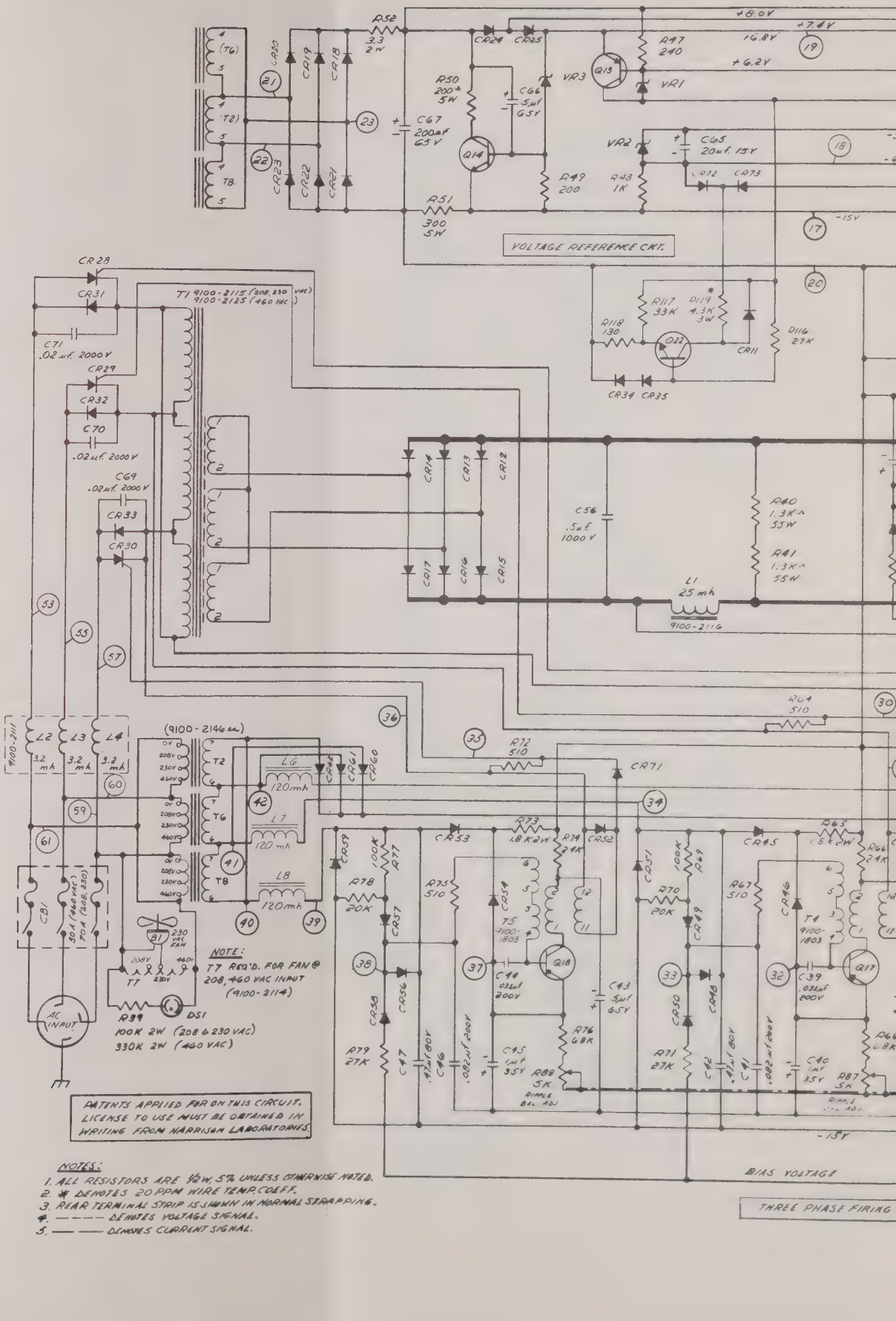
Table 6-4. Replaceable Parts

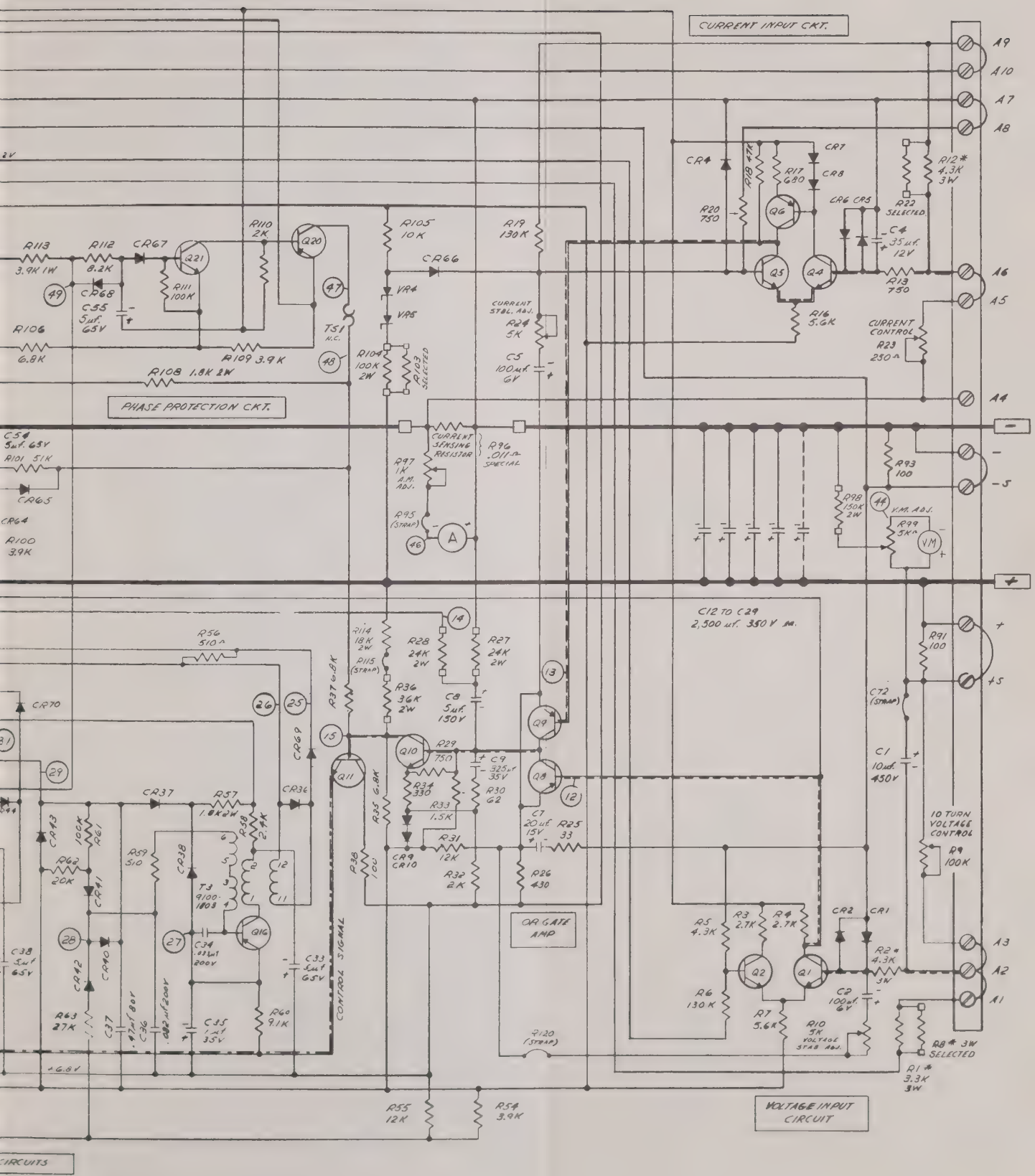
REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
B1	Fan, 230Vac	1	F800-7405-2	26982	3160-0077	1
C1	fxd, elect 10μf 450Vdc	1	D38267	09182	0180-1944	1
C2	fxd, elect 100μf 6Vdc	2	30D107G006DB4	56289	0180-1734	1
C3,6,10,11, 30-32,48-53, 57-64,68	NOT ASSIGNED	-	-	-	-	-
C4	fxd, elect 35μf 12Vdc	1	30D356G012CB4	56289	0180-1837	1
C5	fxd, elect 100μf 6Vdc		30D107G006DB4	56289	0180-1734	
C7	fxd, elect 20μf 15Vdc	2	30D206G015BB4	56289	0180-0300	1
C8	fxd, elect 5μf 150Vdc	1	40D505F150DC4	56289	0180-1841	1
C9	fxd, elect 325μf 35Vdc	1	D34656	09182	0180-0332	1
C12-29	fxd, elect 2,500μf 350Vdc	18	36D252F350DF6B	56289	0180-1844	4
C33	fxd, elect 5μf 65Vdc	6	D33689	09182	0180-1836	2
C34	fxd, film .033μf 200Vdc	3	192P33392	56289	0160-0163	1
C35	fxd, elect 1μf 35Vdc	3	150D105X9035A2	56289	0180-0291	1
C36	fxd, film .082μf 200Vdc	3	192P82392	56289	0160-0167	1
C37	fxd, film .47μf 80Vdc	3	192P4749R8	56289	0160-0970	1
C38	fxd, elect 5μf 65Vdc		D33689	09182	0180-1836	
C39	fxd, film .033μf 200Vdc		192P33392	56289	0160-0163	
C40	fxd, elect 1μf 35Vdc		150D105X9035A2	56289	0180-0291	
C41	fxd, film .082μf 200Vdc		192P82392	56289	0160-0167	
C42	fxd, film .47μf 80Vdc		192P4749R8	56289	0160-0970	
C43	fxd, elect 5μf 65Vdc		D33689	09182	0180-1836	
C44	fxd, film .033μf 200Vdc		192P33392	56289	0160-0163	
C45	fxd, elect 1μf 35Vdc		150D105X9035A2	56289	0180-0291	
C46	fxd, film .082μf 200Vdc		192P82392	56289	0160-0167	
C47	fxd, film .47μf 80Vdc		192P4749R8	56289	0160-0970	
C54,55	fxd, elect 5μf 65Vdc		D33689	09182	0180-1836	
C56	fxd, paper .5μf 1000Vdc	1	P32854	56289	0160-2571	1
C65	fxd, elect 20μf 15Vdc		30D206G015BB4	56289	0180-0300	
C66	fxd, elect 5μf 65Vdc		D33689	09182	0180-1836	
C67	fxd, elect 200μf 65Vdc	1	D70996	09182	0180-1884	1
C69-71	fxd, cer. .02μf 2000Vdc	3	41C321	56289	0160-2569	1
C72	Strap	1	-	-	-	-
CB1*	Circuit breaker 70A, 3 pole	1	GB3-G3-U Curve 3	74193	2110-0216	1
CB1**	Circuit breaker 30A, 3 pole	1	GB3-G3-U Curve 3	74193	2110-0215	1
CR1,2	Rect. Si 200mA 200prv	38	1N485B	93332	1901-0033	12
CR3,26,27, 39,47,55,63	NOT ASSIGNED	-	-	-	-	-
CR4-10	Rect. Si 200mA 200prv		1N485B	93332	1901-0033	
CR11	Rect. Si 500mA 200prv	9	1N3253	93332	1901-0389	6
CR12-14	Power Rect. Si 37A 700prv	6	S3270	58849	1901-0326	6
CR15-17	Power Rect. Si 37A 700prv	3	R3270	58849	1901-0325	3
CR18-25	Rect. Si 500mA 200prv		1N3253	93332	1901-0389	
CR28-30*	SCR 55A 500prv	3	C46E	03508	1884-0035	3
CR28-30**	SCR 63A 800prv	3	251S	05277	1884-0072	3
CR31-33	Power Rect. Si 37A 700prv		S3270	58849	1901-0326	
CR34,35	Rect. Si 200mA 10prv	2	1N4828	03508	1901-0461	2
CR36-38, 40-46,48-54, 56-62,64-68	Rect. Si 200mA 200prv		1N485B	93332	1901-0033	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	℗ PART NO.	RS
CR69-71	Stabistor 2.4V @ 100mA	3	obd	09182	1901-0460	3
CR72,73	Rect. Si 400mA 800prv	2	1N3256	02735	1901-0388	2
DS1	Indicator light, neon	1	599-124	72765	1450-0048	1
L1	Choke, 25mh	1	obd	09182	9100-2116	1
L2A,B,C	Inductor, 3.2mh ea. (set of 3)	1	obd	09182	9100-2111	1
L6-8	Inductor, 140mh	3	obd	09182	5080-7121	1
Q1,2	SS NPN Si	5	2N2714	03508	1854-0027	5
Q3,7,12,15,19	NOT ASSIGNED	-	-	-	-	-
Q4,5	SS NPN Si		2N2714	03508	1854-0027	
Q6,8,9	SS PNP Si	4	2N2907A	03508	1853-0099	4
Q10,11	SS NPN Si	3	2N2193	03508	1854-0244	3
Q13	SS PNP Si		2N2907A	03508	1853-0099	
Q14	SS NPN Si		2N2193	03508	1854-0244	
Q16-18	SS PNP Si (Selected)	3	-	09182	1853-0215	3
Q20	SS PNP Si	1	40362	02735	1853-0041	1
Q21	SS NPN Si.		2N2714	03508	1854-0027	
Q22	SS NPN Si	1	2N3417	03508	1854-0087	1
R1	fxd, ww 3.3KΩ ±5% 3W	1	242E3325	56289	0811-1809	1
R2	fxd, ww 4.3KΩ ±5% 3W	3	242E4325	56289	0811-1811	1
R3,4	fxd, comp 2.7KΩ ±5% ½W	2	EB-2725	01121	0686-2725	1
R5	fxd, comp 4.3KΩ ±5% ½W	1	EB-4325	01121	0686-4325	1
R6	fxd, comp 130KΩ ±5% ½W	2	EB-1345	01121	0686-1345	1
R7	fxd, comp 5.6KΩ ±5% ½W	2	EB-5625	01121	0686-5625	1
R8	fxd, ww Selected ±5% 3W	1	Type 242E obd	56289		
R9	var. ww 100KΩ 10-turn	1	Model 3400 obd	80294	2100-1837	1
R10	var. ww 5KΩ (Modify)	5	Type 110-F4 obd	11236	2100-1824	1
R11,14,15,21, 42-46,53, 80-86,90,92, 94,102,107	NOT ASSIGNED	-	-	-	-	-
R12	fxd, ww 4.3KΩ ±5% 3W		242E4325	56289	0811-1811	
R13	fxd, comp 750Ω ±5% ½W	3	EB-7515	01121	0686-7515	1
R16	fxd, comp 5.6KΩ ±5% ½W		EB-5625	01121	0686-5625	
R17	fxd, comp 680Ω ±5% ½W	1	EB-6815	01121	0686-6815	1
R18	fxd, comp 47KΩ ±5% ½W	1	EB-4735	01121	0686-4735	1
R19	fxd, comp 130KΩ ±5% ½W		EB-1345	01121	0686-1345	
R20	fxd, comp 750Ω ±5% ½W		EB-7515	01121	0686-7515	
R22	fxd, comp Selected ±5% ½W	2	Type EB obd	01121		
R23	var. ww 250Ω	1	obd	09182	2100-1889	1
R24	var. ww 5KΩ (Modify)		Type 110-F4 obd	11236	2100-1824	
R25	fxd, comp 33Ω ±5% ½W	1	EB-3305	01121	0686-3305	1
R26	fxd, comp 430Ω ±5% ½W	1	EB-4315	01121	0686-4315	
R27,28	fxd, met. ox. 24KΩ ±5% 2W	2	Type C42S obd	16299	0763-0021	1
R29	fxd, comp 750Ω ±5% ½W		EB-7515	01121	0686-7515	
R30	fxd, comp 62Ω ±5% ½W	1	EB-6205	01121	0686-6205	1
R31	fxd, comp 12KΩ ±5% ½W	2	EB-1235	01121	0686-1235	1
R32	fxd, comp 2KΩ ±5% ½W	2	EB-2025	01121	0686-2025	1
R33	fxd, comp 1.5KΩ ±5% ½W	1	EB-1525	01121	0686-1525	1
R34	fxd, comp 330Ω ±5% ½W	1	EB-3315	01121	0686-3315	1
R35	fxd, comp 6.8KΩ ±5% ½W	5	EB-6825	01121	0686-6825	1
R36	fxd, met. ox. 36KΩ ±5% 2W	1	Type C42S obd	16299	0698-3651	1
R37	fxd, comp 6.8KΩ ±5% ½W		EB-6825	01121	0686-6825	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R38	fxd, comp 100Ω ±5% ½W	3	EB-1015	01121	0686-1015	1
R39*	fxd, met. ox. 100KΩ ±5% 2W	1	Type C42S obd	16299	0764-0028	1
R39**	fxd, met. ox. 330KΩ ±5% 2W	1	Type C42S obd	16299	0764-0051	1
R40,41	fxd, ww 1.3KΩ ±5% 55W	2	Type 3½BR37 obd	73978	0811-2076	1
R47	fxd, comp 240Ω ±5% ½W	1	EB-2415	01121	0686-2415	1
R48	fxd, comp 1KΩ ±5% ½W	1	EB-1025	01121	0686-1025	1
R49	fxd, comp 200Ω ±5% ½W	1	EB-2015	01121	0686-2015	1
R50	fxd, ww 200Ω ±5% 5W	1	243E2015	56289	0811-1204	1
R51	fxd, ww 300Ω ±5% 5W	1	243E3015	56289	0811-1215	1
R52	fxd, ww 3.3Ω ±5% 2W	1	Type BWH obd	07716	0811-1672	1
R54	fxd, comp 3.9KΩ ±5% ½W	3	EB-3925	01121	0686-3925	1
R55	fxd, comp 12KΩ ±5% ½W		EB-1235	01121	0686-1235	
R56	fxd, comp 510Ω ±5% ½W	6	EB-5115	01121	0686-5115	2
R57	fxd, met. ox. 1.8KΩ ±5% 2W	3	Type C42S obd	16299	0698-3640	1
R58	fxd, comp 2.4KΩ ±5% ½W	3	EB-2425	01121	0686-2425	1
R59	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R60	fxd, comp 9.1KΩ ±5% ½W	1	EB-9125	01121	0686-9125	1
R61	fxd, comp 100KΩ ±5% ½W	4	EB-1045	01121	0686-1045	1
R62	fxd, comp 20KΩ ±5% ½W	3	EB-2035	01121	0686-2035	1
R63	fxd, comp 27KΩ ±5% ½W	4	EB-2735	01121	0686-2735	1
R64	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R65	fxd, met ox. 1.8KΩ ±5% 2W		Type C42S obd	16299	0698-3640	
R66	fxd, comp 2.4KΩ ±5% ½W		EB-2425	01121	0686-2425	
R67	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R68	fxd, comp 6.8KΩ ±5% ½W		EB-6825	01121	0686-6825	
R69	fxd, comp 100KΩ ±5% ½W		EB-1045	01121	0686-1045	
R70	fxd, comp 20KΩ ±5% ½W		EB-2035	01121	0686-2035	
R71	fxd, comp 27KΩ ±5% ½W		EB-2735	01121	0686-2735	
R72	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R73	fxd, met. ox. 1.8KΩ ±5% 2W		Type C42S obd	16299	0698-3640	
R74	fxd, comp 2.4KΩ ±5% ½W		EB-2425	01121	0686-2425	
R75	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R76	fxd, comp 6.8KΩ ±5% ½W		EB-6825	01121	0686-6825	
R77	fxd, comp 100KΩ +5% ½W		EB-1045	01121	0686-1045	
R78	fxd, comp 20KΩ ±5% ½W		EB-2035	01121	0686-2035	
R79	fxd, comp 27KΩ ±5% ½W		EB-2735	01121	0686-2735	
R87,88	var. ww 5KΩ (Modify)		Type 110-F4 obd	11236	2100-1824	
R91,93	fxd, comp 100Ω ±5% ½W		EB-1015	01121	0686-1015	
R95,114,120	STRAP	-	-	-	-	-
R96	fxd, ribbon 11.0mΩ ±40ppm	1	obd	09182	5080-7112	1
R97	var. ww 1KΩ (Modify)	1	Type 110-F4 obd	11236	2100-0391	1
R98	fxd, met. ox. 150KΩ ±5% 2W	1	Type C42S obd	16299	0764-0049	1
R99	var. ww 5KΩ (Modify)		Type 110-F4 obd	11236	2100-1824	
R100	fxd, comp 3.9KΩ ±5% ½W		EB-3925	01121	0686-3925	
R101	fxd, comp 51KΩ ±5% ½W	1	EB-5135	01121	0686-5135	1
R103	fxd, comp Selected ±5% ½W		Type EB obd	01121		
R104	fxd, met. ox. 100KΩ ±5% 2W	1	Type C42S obd	16299	0764-0028	1
R105	fxd, comp 10KΩ ±5% ½W	1	EB-1035	01121	0686-1035	1
R106	fxd, comp 6.8KΩ ±5% ½W		EB-6825	01121	0686-6825	
R108	fxd, met. ox. 1.8KΩ ±5% 2W		Type C42S obd	16299	0698-3640	
R109	fxd, comp 3.9KΩ ±5% ½W		EB-3925	01121	0686-3925	
R110	fxd, comp 2KΩ ±5% ½W		EB-2025	01121	0686-2025	
R111	fxd, comp 100KΩ ±5% ½W		EB-1045	01121	0686-1045	
R112	fxd, comp 8.2KΩ ±5% ½W	1	EB-8225	01121	0686-8225	1
R113	fxd, comp 3.9KΩ ±5% 1W	1	EB-3925	01121	0689-3925	1
R115	fxd, met. ox. 18KΩ ±5% 2W	1	Type C42S obd	16299	0764-0006	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R116	fxd, comp 27KΩ ±5% ½ W		EB-2735	01121	0686-2735	
R117	fxd, comp 33KΩ ±5% ½ W	1	EB-3335	01121	0686-3335	1
R118	fxd, comp 130Ω ±5% ½ W	1	EB-1315	01121	0686-1315	1
R119	fxd, ww 4.3KΩ ±5% 3W		242E4325	56289	0811-1811	
T1*	Power Transformer	1	obd	09182	9100-2115	1
T1**	Power Transformer	1	obd	09182	9100-2125	1
T2	Bias Transformer	2	obd	09182	9100-2146	1
T3-5	Pulse Transformer	3	obd	09182	9100-1803	1
T6	NOT ASSIGNED	-	-	-	-	-
T7***	Fan Transformer	1	obd	09182	9100-2114	1
T8	Bias Transformer		obd	09182	9100-2146	
TS1	Thermostat, N.C. open on rise 167°F ±5°	1	obd	09182	0440-0042	1
VR1,2	Diode, Zener 6.2V ±5%	2	1N821	06486	1902-0761	2
VR3	Diode, Zener 20.5V ±5%	1	1N968	04713	1902-0182	1
VR4,5	Diode, Zener 75V ±5%	2	1N982	04713	1902-3393	2
	MISCELLANEOUS					
	Base Assembly, Welded	1	obd	09182	5060-6132	
	Chassis Assembly, Welded	1	obd	09182	5060-6133	
	Output Chassis, Rear	1	obd	09182	5000-6115	
	Grommet, Output Chassis	2	1655	73734	0400-0042	
	Spacer, Insulated, Output Chassis	3	obd	86838	0380-0709	
	Cover, Top	1	obd	09182	5000-6116	
	Cover, Rear	1	obd	09182	5000-6117	
	Front Panel, Upper	1	obd	09182	06477-60001	
	Front Panel, Lower, Vented	1	obd	09182	5000-6122	
	Screen, Lower Front Panel	1	obd	09182	5000-6135	
	Heat Sink, SCR	3	obd	09182	5020-5536	
	Plate Insulated, SCR's	3	obd	09182	5020-5720	
	Spacer, Insulated, SCR Heat Sink (2-3/8" lg.)	6	obd	86838	0380-0713	
	Spacer, Insulated, SCR Heat Sink (2-1/8" lg.)	6	obd	86838	0380-0712	
	Heat Sink, Rectifier	2	obd	09182	5020-5564	
	Bracket, Rect. Heat Sink	2	obd	09182	5000-6131	
	Spacer, Insulated, Rect. Heat Sink	2	obd	09182	0380-0714	
	Shoulder Washer, Rect. H. Sink Bkt.	8	obd	09182	2190-0492	
	Buss Bar, Internal (+)	1	obd	09182	5000-6127	
	Buss Bar, Internal (-)	1	obd	09182	5000-6128	
	Buss Bar, Output (+)	1	obd	09182	5000-6129	
	Buss Bar, Output (-)	1	obd	09182	5000-6130	
	Cover, Buss Bar	1	obd	09182	5000-6136	
	Standoff, Aluminum, Output Busses	5	obd	09182	0380-0394	
	Buss Bar, C12-C29 (14-3/4" lg.)	1	obd	09182	5000-6124	
	Buss Bar, C12-C29 (13-7/8" lg.)	1	obd	09182	5000-6125	
	Buss Bar, C12-C29	3	obd	09182	5000-6126	
	Baffle, Fan	1	obd	09182	5000-6118	
	Clamp, C12-C29	4	obd	09182	5000-6119	
	P.C. Board, Includes Components	1	obd	09182	06477-60020	
	P.C. Board, Blank	1	obd	09182	5020-5548	
	Transistor Socket (Q10, 11, 16-18)	5	3305	91662	1200-0708	


+8.0V
+7.4V
+6.2V
-15V
-13V
VOLTAGE REFERENCE CKT.
BIAS VOLTAGE
THREE PHASE FIRING
T1 9100-2115 (208,230 VAC) 9100-2125 (460 VAC)
(9100-2146 ea)
T2
T6
T8
T5 9100-1803
T4 9100-1803
L1 25 mh 9100-2116
L2
L3
L4
L6 120mh
L7 120 mh
L8 120mh
CB1
B1 230 VAC FAN
T7
DS1
AC INPUT
R39 100K 2W (208 & 230 VAC) 330K 2W (460 VAC)
NOTE: T7 REQ'D. FOR FAN @ 208,460 VAC INPUT (9100-2114)
PATENTS APPLIED FOR ON THIS CIRCUIT. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HARRISON LABORATORIES.
NOTES:
1. ALL RESISTORS ARE ½W, 5% UNLESS OTHERWISE NOTED.
2. * DENOTES 20 PPM WIRE TEMP. COEFF.
3. REAR TERMINAL STRIP IS SHOWN IN NORMAL STRAPPING.
4. ——— DENOTES VOLTAGE SIGNAL.
5. —— —— DENOTES CURRENT SIGNAL.



Model 6477A, Schematic Diagram

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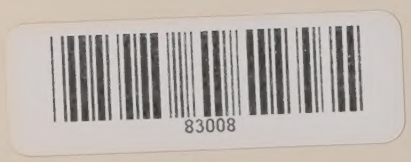

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